

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 1
Foundations of Engineering Economy

- 1.1** The four elements are cash flows, time of occurrence of cash flows, interest rates, and measure of economic worth.
- 1.2** (a) Capital funds are money used to finance projects. It is usually limited in the amount of money available.
- (b) Sensitivity analysis is a procedure that involves changing various estimates to see if/how they affect the economic decision.
- 1.3** Any of the following are measures of worth: present worth, future worth, annual worth, rate of return, benefit/cost ratio, capitalized cost, payback period, economic value added.
- 1.4** First cost: *economic*; leadership: *non-economic*; taxes: *economic*; salvage value: *economic*; morale: *non-economic*; dependability: *non-economic*; inflation: *economic*; profit: *economic*; acceptance: *non-economic*; ethics: *non-economic*; interest rate: *economic*.
- 1.5** Many sections could be identified. Some are: I.b; II.2.a and b; III.9.a and b.
- 1.6** Example actions are:
- Try to talk them out of doing it now, explaining it is stealing
 - Try to get them to pay for their drinks
 - Pay for all the drinks himself
 - Walk away and not associate with them again
- 1.7** *This is structured to be a discussion question; many responses are acceptable.* It is an ethical question, but also a guilt-related situation. He can justify the result as an accident; he can feel justified by the legal fault and punishment he receives; he can get angry because it WAS an accident; he can become tormented over time due to the stress caused by accidentally causing a child's death.
- 1.8** *This is structured to be a discussion question; many responses are acceptable.* Responses can vary from the ethical (stating the truth and accepting the consequences) to unethical (continuing to deceive himself and the instructor and devise some on-the-spot excuse).

Lessons can be learned from the experience. A few of them are:

- Think before he cheats again.
- Think about the longer-term consequences of unethical decisions.
- Face ethical-dilemma situations honestly and make better decisions in real time.

Alternatively, Claude may learn nothing from the experience and continue his unethical practices.

1.9 $i = [(3,885,000 - 3,500,000)/3,500,000]*100\% = 11\%$ per year

1.10 (a) Amount paid first four years = $900,000(0.12) = \$108,000$

(b) Final payment = $900,000 + 900,000(0.12) = \$1,008,000$

1.11 $i = (1125/12,500)*100 = 9\%$
 $i = (6160/56,000)*100 = 11\%$
 $i = (7600/95,000)*100 = 8\%$

The \$56,000 investment has the highest rate of return.

1.12 Interest on loan = $23,800(0.10) = \$2,380$
Default insurance = $23,800(0.05) = \$1190$
Set-up fee = \$300

Total amount paid = $2380 + 1190 + 300 = \$3870$

Effective interest rate = $(3870/23,800)*100 = 16.3\%$

1.13 The market interest rate is usually 3 – 4 % above the expected inflation rate. Therefore,

Market rate is in the range $3 + 8$ to $4 + 8 = 11$ to 12% per year

1.14 PW = present worth; PV = present value; NPV = net present value; DCF = discounted cash flow; and CC = capitalized cost

1.15 $P = \$150,000$; $F = ?$; $i = 11\%$; $n = 7$

1.16 $P = ?$; $F = \$100,000$; $i = 12\%$; $n = 2$

1.17 $P = \$3.4$ million; $A = ?$; $i = 10\%$; $n = 8$

1.18 $F = ?$; $A = \$100,000 + \$125,000?$; $i = 15\%$; $n = 3$

1.19 End-of-period convention means that all cash flows are assumed to take place at the end of the interest period in which they occur.

1.20 fuel cost: *outflow*; pension plan contributions: *outflow*; passenger fares: *inflow*; maintenance: *outflow*; freight revenue: *inflow*; cargo revenue: *inflow*; extra bag charges: *Inflow*; water and sodas: *outflow*; advertising: *outflow*; landing fees: *outflow*; seat preference fees: *inflow*.

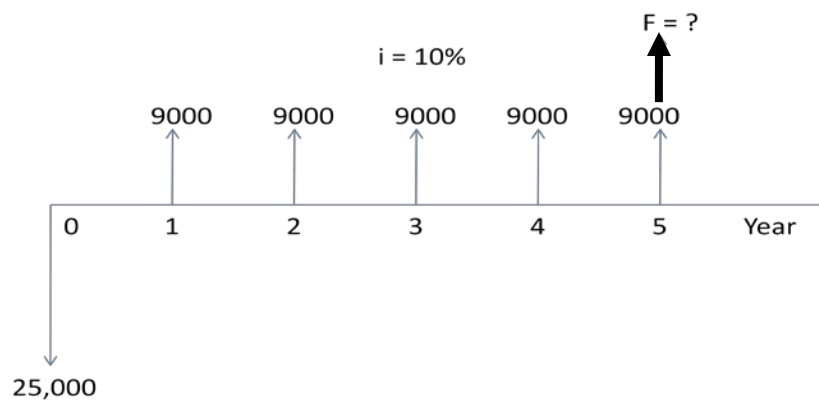
1.21 End-of-period amount for June = $50 + 70 + 120 + 20 = \$260$

End-of-period amount for Dec = $150 + 90 + 40 + 110 = \$390$

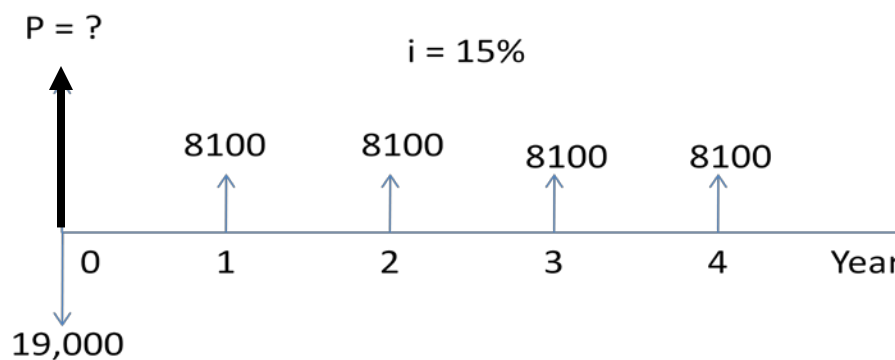
1.22 Month	Receipts, \$1000	Disbursements, \$1000	Net CF, \$1000
Jan	500	300	+200
Feb	800	500	+300
Mar	200	400	-200
Apr	120	400	-280
May	600	500	+100
June	900	600	+300
July	800	300	+500
Aug	700	300	+400
Sept	900	500	+400
Oct	500	400	+100
Nov	400	400	0
Dec	1800	700	<u>+1100</u>

Net Cash flow = \$2,920 (\$2,920,000)

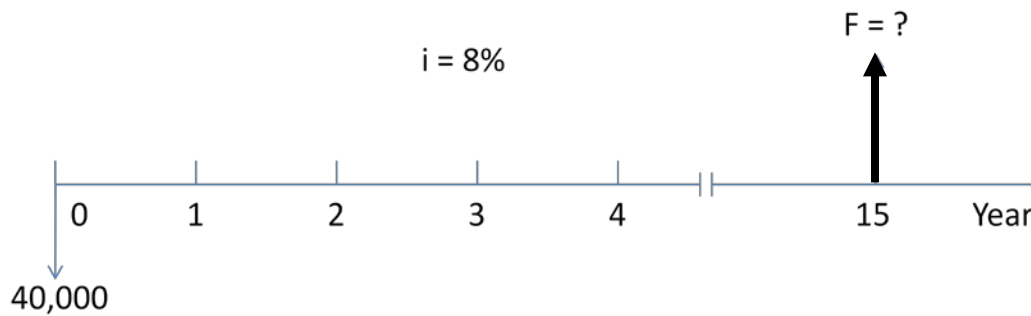
1.23



1.24



1.25



1.26 Amount now = $F = 100,000 + 100,000(0.15) = \$115,000$

1.27 Equivalent present amount = $1,000,000/(1 + 0.15)$
 $= \$869,565$

Discount = $790,000 - 869,565$
 $= \$79,565$

1.28 $5000(40)(1 + i) = 225,000$
 $1 + i = 1.125$
 $i = 0.125 = 12.5\% \text{ per year}$

1.29 Total bonus next year = $8,000 + 8,000(1.08)$
 $= \$16,640$

1.30 (a) Early-bird payment = $10,000 - 10,000(0.10) = \9000

(b) Equivalent future amount = $9000(1 + 0.10) = \$9900$

Savings = $10,000 - 9900 = \$100$

1.31 $F_1 = 1,000,000 + 1,000,000(0.10)$
 $= 1,100,000$

$F_2 = 1,100,000 + 1,100,000(0.10)$
 $= \$1,210,000$

1.32 $90,000 = 60,000 + 60,000(5)(i)$
 $300,000 i = 30,000$
 $i = 0.10 \quad (10\% \text{ per year})$

1.33 (a) $F = 1,800,000(1 + 0.10)(1 + 0.10) = \$2,178,000$

(b) Interest = $2,178,000 - 1,800,000 = \$378,000$

$$\begin{aligned} 1.34 \quad F &= 6,000,000(1 + 0.09)(1 + 0.09)(1 + 0.09) \\ &= \$7,770,174 \end{aligned}$$

$$\begin{aligned} 1.35 \quad 4,600,000 &= P(1 + 0.10)(1 + 0.10) \\ P &= \$3,801,653 \end{aligned}$$

$$\begin{aligned} 1.36 \quad 86,400 &= 50,000(1 + 0.20)^n \\ \log(86,400/50,000) &= n(\log 1.20) \\ 0.23754 &= 0.07918n \\ n &= 3 \text{ years} \end{aligned}$$

$$\begin{aligned} 1.37 \quad \text{Simple: } F &= 10,000 + 10,000(3)(0.10) \\ &= \$13,000 \end{aligned}$$

$$\begin{aligned} \text{Compound: } 13,000 &= 10,000(1 + i)(1 + i)(1 + i) \\ (1 + i)^3 &= 1.3000 \\ 3\log(1 + i) &= \log 1.3 \\ 3\log(1 + i) &= 0.1139 \\ \log(1 + i) &= 0.03798 \\ 1 + i &= 1.091 \\ i &= 9.1\% \text{ per year} \end{aligned}$$

1.38 Minimum attractive rate of return is also referred to as hurdle rate, cutoff rate, benchmark rate, and minimum acceptable rate of return.

1.39 bonds - *debt*; stock sales - *equity*; retained earnings - *equity*; venture capital - *debt*; short term loan - *debt*; capital advance from friend - *debt*; cash on hand - *equity*; credit card - *debt*; home equity loan - *debt*.

$$1.40 \quad WACC = 0.30(8\%) + 0.70(13\%) = 11.5\%$$

$$1.41 \quad WACC = 10\%(0.09) + 90\%(0.16) = 15.3\%$$

The company should undertake the inventory, technology, and warehouse projects.

- 1.42 (a) PV(i%,n,A,F) finds the present value P
 (b) FV(i%,n,A,P) finds the future value F
 (c) RATE(n,A,P,F) finds the compound interest rate i
 (d) IRR(first_cell:last_cell) finds the compound interest rate i
 (e) PMT(i%,n,P,F) finds the equal periodic payment A
 (f) NPER(i%,A,P,F) finds the number of periods n

- 1.43** (a) NPER(8%, -1500, 8000, 2000): $i = 8\%$; $A = \$-1500$; $P = \$8000$; $F = \$2000$; $n = ?$
 (b) FV(6%, 10, 2000, -9000): $i = 6\%$; $n = 10$; $A = \$2000$; $P = \$-9000$; $F = ?$
 (c) RATE(10, 1000, -12000, 2000): $n = 10$; $A = \$1000$; $P = \$-12,000$; $F = \$2000$; $i = ?$
 (d) PMT(11%, 20, , 14000): $i = 11\%$; $n = 20$; $F = \$14,000$; $A = ?$
 (e) PV(8%, 15, -1000, 800): $i = 8\%$; $n = 15$; $A = \$-1000$; $F = \$800$; $P = ?$

- 1.44** (a) PMT is A (b) FV is F (c) NPER is n (d) PV is P (e) IRR is i

- 1.45** (a) For built-in functions, a parameter that does not apply can be left blank when it is not an interior one. For example, if there is no F involved when using the PMT function to solve a particular problem, it can be left blank (omitted) because it is an end parameter.
 (b) When the parameter involved is an interior one (like P in the PMT function), a comma must be put in its position.

- 1.46** Spreadsheet shows relations only in cell reference format. Cell E10 will indicate \$64 more than cell C10.

	A	B	C	D	E
1	Initial amount =	1000		i =	0.1
2					
3		Simple		Compound	
4	Year	Interest, \$	Total, \$	Interest, \$	Total, \$
5	0		= \$B\$1		= \$B\$1
6	1	= \$B\$1*\$E\$1	= C5 + B6	= \$E5 * \$E\$1	= E5 + D6
7	2	= \$B\$1*\$E\$1	= C6 + B7	= \$E6 * \$E\$1	= E6 + D7
8	3	= \$B\$1*\$E\$1	= C7 + B8	= \$E7 * \$E\$1	= E7 + D8
9	4	= \$B\$1*\$E\$1	= C8 + B9	= \$E8 * \$E\$1	= E8 + D9
10	Total	=SUM(B6:B9)	= C9	=SUM(D6:D9)	= E9

- 1.47** Answer is (b)

- 1.48** Answer is (d)

- 1.49** Answer is (a)

- 1.50** Answer is (d)

- 1.51** Upper limit = $(12,300 - 10,700)/10,700 = 15\%$
 Lower limit = $(10,700 - 8,900)/10,700 = 16.8\%$

Answer is (c)

- 1.52** Amount one year ago = $10,000/(1 + 0.10) = \$9090.90$

Answer is (b)

1.53 Answer is (c)

1.54 $2P = P + P(n)(0.04)$

$$1 = 0.04n$$

$$n = 25$$

Answer is (b)

1.55 Answer is (a)

1.56 $WACC = 0.70(16\%) + 0.30(12\%)$
 $= 14,8\%$

Answer is (c)

Solution to Case Studies, Chapter 1

There is no definitive answer to case study exercises. The following are examples only.

Renewable Energy Sources for Electricity Generation

3. LEC approximation uses $(1.05)^{11} = 0.5847$, $X = P_{11} + A_{11} + C_{11}$ and LEC last year = 0.1022.

$$0.1027 = 0.1022 + \frac{X(0.5847)}{(5.052 B)(0.5847)}$$

$$X = \$2.526 \text{ million}$$

Refrigerator Shells

1. The first four steps are: Define objective, information collection, alternative definition and estimates, and criteria for decision-making.

Objective: Select the most economic alternative that also meets requirements such as production rate, quality specifications, manufacturability for design specifications, etc.

Information: Each alternative must have estimates for life (likely 10 years), AOC and other costs (e.g., training), first cost, any salvage value, and the MARR. The debt versus equity capital question must be addressed, especially if more than \$5 million is needed.

Alternatives: For both A and B, some of the required data to perform an analysis are:

P and S must be estimated.

AOC equal to about 8% of P must be verified.

Training and other cost estimates (annual, periodic, one-time) must be finalized.

Confirm $n = 10$ years for life of A and B.

MARR will probably be in the 15% to 18% per year range.

Criteria: Can use either present worth or annual worth to select between A and B.

2. Consider these and others like them:

Debt capital availability and cost

Competition and size of market share required

Employee safety of plastics used in processing

3. With the addition of C, this is now a make/buy decision. Economic estimates needed are:

- Cost of lease arrangement or unit cost, whatever is quoted.
- Amount and length of time the arrangement is available.

Some non-economic factors may be:

- Guarantee of available time as needed.
- Compatibility with current equipment and designs.
- Readiness of the company to enter the market now versus later

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Chapter 2
Factors: How Time and Interest Affect Money

2.1 (1) $(P/F, 6\%, 8) = 0.6274$
(2) $(A/P, 10\%, 10) = 0.16275$
(3) $(A/G, 15\%, 20) = 5.3651$
(4) $(A/F, 2\%, 30) = 0.02465$
(5) $(P/G, 35\%, 15) = 7.5974$

2.2 $P = 21,300(P/A, 10\%, 5)$
 $= 21,300(3.7908)$
 $= \$80,744$

2.3 Cost now $= 142(0.60)$
 $= \$85.20$
Present worth at regular cost $= 142(P/F, 10\%, 2)$
 $= 142(0.8264)$
 $= \$117.35$

Present worth of savings $= 117.35 - 85.20$
 $= \$32.15$

2.4 $F = 100,000(F/P, 10\%, 3) + 885,000$
 $= 100,000(1.3310) + 885,000$
 $= \$1,018,100$

2.5 $F = 50,000(F/P, 6\%, 14)$
 $= 50,000(2.2609)$
 $= \$113,045$

2.6 $F = 1,900,000(F/P, 15\%, 3)$
 $F = 1,900,000(1.5209)$
 $= \$2,889,710$

2.7 $A = 220,000(A/P, 10\%, 3)$
 $= 220,000(0.40211)$
 $= \$88,464$

2.8 $P = 75,000(P/F, 12\%, 4)$
 $= 75,000(0.6355)$
 $= \$47,663$

$$\begin{aligned}
2.9 \quad F &= 1.3(F/P, 18\%, 10) \\
&= 1.3(5.2338) \\
&= 6.80394 \quad (\$6,803,940)
\end{aligned}$$

$$\begin{aligned}
2.10 \quad P &= 200,000(P/F, 15\%, 1) + 300,000(P/F, 15\%, 3) \\
&= 200,000(0.8696) + 300,000(0.6575) \\
&= \$371,170
\end{aligned}$$

$$2.11 \quad \text{Gain in worth of building after repairs} = (600,000/0.75 - 600,000) - 25,000 = 175,000$$

$$\begin{aligned}
F &= 175,000(F/P, 8\%, 5) \\
&= 175,000(1.4693) \\
&= \$257,128
\end{aligned}$$

$$\begin{aligned}
2.12 \quad F &= 100,000(F/P, 8\%, 4) + 150,000(F/P, 8\%, 3) \\
&= 100,000(1.3605) + 150,000(1.2597) \\
&= \$325,005
\end{aligned}$$

$$\begin{aligned}
2.13 \quad P &= (110,000 * 0.3)(P/A, 12\%, 4) \\
&= (33,000)(3.0373) \\
&= \$100,231
\end{aligned}$$

$$\begin{aligned}
2.14 \quad P &= 600,000(0.04)(P/A, 10\%, 3) \\
&= 24,000(2.4869) \\
&= \$59,686
\end{aligned}$$

$$\begin{aligned}
2.15 \quad A &= 950,000(A/P, 6\%, 20) \\
&= 950,000(0.08718) \\
&= \$82,821
\end{aligned}$$

$$\begin{aligned}
2.16 \quad A &= 434(A/P, 8\%, 5) \\
&= 434(0.25046) \\
&= \$108.70
\end{aligned}$$

$$\begin{aligned}
2.17 \quad F &= (0.18 - 0.04)(100)(F/A, 6\%, 8) \\
&= 14(9.8975) \\
&= \$138.57
\end{aligned}$$

$$\begin{aligned}
2.18 \quad F_{\text{difference}} &= 10,500(F/P, 7\%, 18) - 10,500(F/P, 4\%, 18) \\
&= 10,500(3.3799) - 10,500(2.2058) \\
&= \$12,328
\end{aligned}$$

$$\begin{aligned}
2.19 \quad F &= (200 - 90)(F/A, 10\%, 8) \\
&= 110(11.4359) \\
&= \$1,257,949
\end{aligned}$$

$$\begin{aligned}
2.20 \quad A &= 350,000(A/F, 10\%, 3) \\
&= 350,000(0.30211) \\
&= \$105,739
\end{aligned}$$

2.21 (a) 1. Interpolate between $i = 12\%$ and $i = 14\%$ at $n = 15$.

$$\begin{aligned}
1/2 &= x/(0.17102 - 0.14682) \\
x &= 0.0121
\end{aligned}$$

$$\begin{aligned}
(A/P, 13\%, 15) &= 0.14682 + 0.0121 \\
&= 0.15892
\end{aligned}$$

2. Interpolate between $i = 25\%$ and $i = 30\%$ at $n = 10$.

$$\begin{aligned}
2/5 &= x/(9.9870 - 7.7872) \\
x &= 0.8799
\end{aligned}$$

$$\begin{aligned}
(P/G, 27\%, 10) &= 9.9870 - 0.8799 \\
&= 9.1071
\end{aligned}$$

$$\begin{aligned}
(b) \quad 1. \quad (A/P, 13\%, 15) &= [0.13(1 + 0.13)^{15}] / [(1 + 0.13)^{15} - 1] \\
&= 0.15474
\end{aligned}$$

$$\begin{aligned}
2. \quad (P/G, 27\%, 10) &= [(1 + 0.27)^{10} - (0.27)(10) - 1] / [0.27^2(1 + 0.27)^{10}] \\
&= 9.0676
\end{aligned}$$

2.22 (a) 1. Interpolate between $n = 60$ and $n = 65$:

$$\begin{aligned}
2/5 &= x/(4998.22 - 2595.92) \\
x &= 960.92
\end{aligned}$$

$$\begin{aligned}
(F/P, 14\%, 62) &= 4998.22 - 960.92 \\
&= 4037.30
\end{aligned}$$

2. Interpolate between $n = 40$ and $n = 48$:

$$\begin{aligned}
5/8 &= x/(0.02046 - 0.01633) \\
x &= 0.00258
\end{aligned}$$

$$\begin{aligned}
(A/F, 1\%, 45) &= 0.02046 - 0.00258 \\
&= 0.01788
\end{aligned}$$

$$\begin{aligned}
(b) \quad 1. \quad (F/P, 14\%, 62) &= (1 + 0.14)^{62} - 1 \\
&= 3373.66
\end{aligned}$$

$$\begin{aligned}
2. \quad (A/F, 1\%, 45) &= 0.01 / [(1 + 0.01)^{45} - 1] \\
&= 0.01771
\end{aligned}$$

(c) 1. = -FV(14%,62,,1) displays 3373.66

3. = PMT(1%,45,,1) displays 0.01771

2.23 Interpolated value: Interpolate between n = 40 and n = 45:

$$\begin{aligned} 3/5 &= x/(72.8905 - 45.2593) \\ x &= 16.5787 \end{aligned}$$

$$\begin{aligned} (F/P, 10\%, 43) &= 45.2593 + 16.5787 \\ &= 61.8380 \end{aligned}$$

$$\text{Formula value: } (F/P, 10\%, 43) = (1 + 0.10)^{43} - 1 = 59.2401$$

$$\% \text{ difference} = [(61.8380 - 59.2401) / 59.2401] * 100 = 4.4\%$$

2.24 Interpolated value: Interpolate between n = 50 and n = 55:

$$\begin{aligned} 2/5 &= x/(14524 - 7217.72) \\ x &= 2922.51 \end{aligned}$$

$$\begin{aligned} (F/A, 15\%, 52) &= 7217.72 + 2922.51 \\ &= 10,140 \end{aligned}$$

$$\text{Formula value: } (F/A, 15\%, 52) = [(1 + 0.15)^{52} - 1] / 0.15 = 9547.58$$

$$\begin{aligned} \% \text{ difference} &= [(10,140 - 9547.58) / 9547.58] (100) \\ &= 6.2\% \end{aligned}$$

2.25 (a) Profit in year 5 = 6000 + 1100(4) = \$10,400

$$\begin{aligned} \text{(b) } P &= 6000(P/A, 8\%, 5) + 1100(P/G, 8\%, 5) \\ &= 6000(3.9927) + 1100(7.3724) \\ &= \$32,066 \end{aligned}$$

2.26 (a) $G = (241 - 7)/9 = \$26$ billion per year

$$\text{(b) Loss in year 5} = 7 + 4(26) = \$111 \text{ billion}$$

$$\begin{aligned} \text{(c) } A &= 7 + 26(A/G, 8\%, 10) \\ &= 7 + 26(3.8713) \\ &= \$107.7 \text{ billion} \end{aligned}$$

$$\begin{aligned} \text{2.27 } A &= 200 - 5(A/G, 8\%, 8) \\ &= 200 - 5(3.0985) \\ &= \$184.51 \end{aligned}$$

$$\begin{aligned}
2.28 \quad P &= 60,000(P/A, 10\%, 5) + 10,000(P/G, 10\%, 5) \\
&= 60,000(3.7908) + 10,000(6.8618) \\
&= \$296,066
\end{aligned}$$

$$2.29 \quad (a) \quad CF_3 = 70 + 3(4) = \$82 \quad (\$82,000)$$

$$\begin{aligned}
(b) \quad P &= 74(P/A, 10\%, 10) + 4(P/G, 10\%, 10) \\
&= 74(6.1446) + 4(22.8913) \\
&= \$546.266 \quad (\$546,266)
\end{aligned}$$

$$\begin{aligned}
F &= 546.266(F/P, 10\%, 10) \\
&= 521.687(2.5937) \\
&= \$1416.850 \quad (\$1,416,850)
\end{aligned}$$

$$\begin{aligned}
2.30 \quad 601.17 &= A + 30(A/G, 10\%, 9) \\
601.17 &= A + 30(3.3724) \\
A &= \$500
\end{aligned}$$

$$\begin{aligned}
2.31 \quad P &= 2.1B (P/F, 18\%, 5) \\
&= 2.1B (0.4371) \\
&= \$917,910,000
\end{aligned}$$

$$\begin{aligned}
917,910,000 &= 50,000,000(P/A, 18\%, 5) + G(P/G, 18\%, 5) \\
917,910,000 &= 50,000,000(3.1272) + G(5.2312) \\
G &= \$14,557,845
\end{aligned}$$

$$\begin{aligned}
2.32 \quad 75,000 &= 15,000 + G(A/G, 10\%, 5) \\
75,000 &= 15,000 + G(1.8101) \\
G &= \$33,147
\end{aligned}$$

2.33 First find P_g (using equation) and then convert to A

$$\begin{aligned}
\text{For } n = 1: P_g &= \{1 - [(1 + 0.04)/(1 + 0.10)]^1\} / (0.10 - 0.04) \\
&= 0.90909
\end{aligned}$$

$$\begin{aligned}
A &= 0.90909(A/P, 10\%, 1) \\
&= 0.90909(1.1000) \\
&= 1.0000
\end{aligned}$$

$$\begin{aligned}
\text{For } n = 2: P_g &= \{1 - [(1 + 0.04)/(1 + 0.10)]^2\} / (0.10 - 0.04) \\
&= 1.7686
\end{aligned}$$

$$\begin{aligned}
A &= 1.7686(A/P, 10\%, 2) \\
&= 1.7686(0.57619) \\
&= 1.0190
\end{aligned}$$

$$\begin{aligned} 2.34 \quad P_g &= 50,000\{1 - [(1 + 0.06)/(1 + 0.10)]^8\}/(0.10 - 0.06) \\ &= \$320,573 \end{aligned}$$

$$\begin{aligned} 2.35 \quad P_{g1} &= 10,000\{1 - [(1 + 0.04)/(1 + 0.08)]^{10}\}/(0.08 - 0.04) \\ &= \$78,590 \end{aligned}$$

$$\begin{aligned} P_{g2} &= 10,000\{1 - [(1 + 0.06)/(1 + 0.08)]^{11}\}/(0.08 - 0.06) \\ &= \$92,926 \end{aligned}$$

$$\text{Difference} = \$14,336$$

$$\begin{aligned} 2.36 \quad P_g &= 260\{1 - [(1 + 0.04)/(1 + 0.06)]^{20}\}/(0.06 - 0.04) \\ &= 260(15.8399) \\ &= \$4118.37 \text{ per acre-ft} \end{aligned}$$

$$2.37 \quad P = 30,000[10/(1 + 0.06)] = \$283,019$$

$$\begin{aligned} 2.38 \quad 18,000,000 &= 3,576,420(P/A, i, 7) \\ (P/A, i, 7) &= 5.0330 \end{aligned}$$

From interest tables in P/A column and $n = 7$, $i = 9\%$ per year.

Can be solved using the RATE function = RATE(7,3576420,18000000).

$$\begin{aligned} 2.39 \quad 813,000 &= 170,000(F/P, i, 15) \\ 813,000 &= 170,000(1 + i)^{15} \end{aligned}$$

$$\begin{aligned} \log 4.78235 &= (15)\log (1 + i) \\ 0.6796/15 &= \log (1 + i) \\ \log (1 + i) &= 0.04531 \end{aligned}$$

$$\begin{aligned} 1 + i &= 1.11 \\ i &= 11 \% \text{ per year} \end{aligned}$$

Can be solved using the RATE function = RATE(15,,-170000,813000).

$$\begin{aligned} 2.40 \quad 100,000 &= 210,325(P/F, i, 30) \\ (P/F, i, 30) &= 0.47545 \end{aligned}$$

Find i by interpolation between 2% and 3%, by solving the P/F equation for i , or by spreadsheet. By spreadsheet function = RATE(30,,100000,-210325), $i = 2.51\%$.

$$\begin{aligned} 2.41 \quad (1,000,000 - 1,900,000) &= 200,000(F/P, i, 4) \\ (F/P, i, 4) &= 4.5 \end{aligned}$$

Find i by interpolation between 40% and 50%, by solving F/P equation, or by spreadsheet.
By spreadsheet function = RATE(4,,-200000,900000), $i = 45.7\%$ per year.

$$\begin{aligned} 2.42 \quad 800,000 &= 250,000(P/A, i, 5) \\ (P/A, i, 5) &= 3.20 \end{aligned}$$

Interpolate between 16% and 18% interest tables or use a spreadsheet. By spreadsheet function, $i = 16.99\% \approx 17\%$ per year.

$$\begin{aligned} 2.43 \quad 87,360 &= 24,000(F/A, i, 3) \\ (F/A, i, 3) &= 3.6400 \end{aligned}$$

For $n = 3$ in F/A column, 3.6400 is in 20% interest table. Therefore, $i = 20\%$ per year.

$$\begin{aligned} 2.44 \quad 48,436 &= 42,000 + 4000(A/G, i, 5) \\ 6436 &= 4000(A/G, i, 5) \\ (A/G, i, 5) &= 1.6090 \end{aligned}$$

For $n = 5$ in A/G column, value of 1.6090 is in 22% interest table.

$$\begin{aligned} 2.45 \quad 600,000 &= 80,000(F/A, 15\%, n) \\ (F/A, 15\%, n) &= 7.50 \end{aligned}$$

Interpolate in the 15% interest table or use a spreadsheet function. By spreadsheet, $n = 5.4$ years.

$$2.46 \quad \text{Starting amount} = 1,600,000(0.55) = \$880,000$$

$$\begin{aligned} 1,600,000 &= 880,000(F/P, 9\%, n) \\ (F/P, 9\%, n) &= 1.8182 \end{aligned}$$

Interpolate in 9% interest table or use the spreadsheet function
= NPER(9%,,-880000,1600000) to determine that $n = 6.94 \approx 7$ years.

$$\begin{aligned} 2.47 \quad 200,000 &= 29,000(P/A, 10\%, n) \\ (P/A, 10\%, n) &= 6.8966 \end{aligned}$$

Interpolate in 10% interest table or use a spreadsheet function to display $n = 12.3$ years.

$$\begin{aligned} 2.48 \quad 1,500,000 &= 18,000(F/A, 12\%, n) \\ (F/A, 12\%, n) &= 83.3333 \end{aligned}$$

Interpolate in 12% interest table or use the spreadsheet function

= NPER(12%, -18000,,1500000) to display $n = 21.2$ years. Time from now is

$$21.2 - 15 = 6.2 \text{ years.}$$

2.49 $350,000 = 15,000(P/A, 4\%, n) + 21,700(P/G, 4\%, n)$

Solve by trial and error in 4% interest table between 5 and 6 years to determine $n \approx 6$ years

2.50 $16,000 = 13,000 + 400(A/G, 8\%, n)$
 $(A/G, 8\%, n) = 7.5000$

Interpolate in 8% interest table or use a spreadsheet to determine that $n = 21.8$ years.

2.51 $140(0.06 - 0.03) = 12\{1 - [(0.97170)]^x\}$
 $4.2/12 = 1 - [0.97170]^x$
 $0.35 - 1 = -[0.97170]^x$
 $0.65 = [0.97170]^x$

$$\log 0.65 = (x)(\log 0.97170)$$
$$x = 15 \text{ years}$$

2.52 $135,300 = 35,000 + 19,000(A/G, 10\%, n)$
 $100,300 = 19,000(A/G, 10\%, n)$
 $(A/G, 10\%, n) = 5.2789$

From A/G column in 10% interest table, $n = 15$ years.

2.53 $88,146 = 25,000\{1 - [(1 + 0.18)/(1 + 0.10)]^n\}/(0.10 - 0.18)$
 $3.52584 = \{1 - [(1.18)/(1.10)]^n\}/(-.08)$
 $-0.28207 = \{1 - [(1.18)/(1.10)]^n\}$
 $-1.28207 = -[(1.18)/(1.10)]^n$
 $1.28207 = [(1.07273)]^n$

$$\log 1.28207 = n \log 1.07273$$
$$0.10791 = n(0.03049)$$
$$n = 3.54 \text{ years}$$

2.54 $P = 30,000(P/F, 12\%, 3)$
 $= 30,000(0.7118)$
 $= \$21,354$

Answer is (d)

$$\begin{aligned} 2.55 \quad 30,000 &= 4200(P/A, 8\%, n) \\ (P/A, 8\%, n) &= 7.14286 \end{aligned}$$

n is between 11 and 12 years

Answer is (c)

$$2.56 \quad A = 22,000 + 1000(A/G, 8\%, 5) = \$23,847$$

Answer is (a)

2.57 Answer is (d)

$$2.58 \quad A = 800 - 100(A/G, 4\%, 6) = \$561.43$$

Answer is (b)

2.59 Answer is (b)

$$\begin{aligned} 2.60 \quad F &= 61,000(F/P, 4\%, 4) \\ &= 61,000(1.1699) \\ &= \$71,364 \end{aligned}$$

Answer is (c)

$$\begin{aligned} 2.61 \quad P &= 90,000(P/A, 10\%, 10) \\ &= 90,000(6.1446) \\ &= \$553,014 \end{aligned}$$

Answer is (d)

$$\begin{aligned} 2.62 \quad A &= 100,000(A/P, 10\%, 7) \\ &= 100,000(0.20541) \\ &= \$20,541 \end{aligned}$$

Answer is (b)

$$\begin{aligned} 2.63 \quad A &= 1,500,000(A/F, 10\%, 20) \\ &= 1,500,000(0.01746) \\ &= \$26,190 \end{aligned}$$

Answer is (a)

2.64 In \$1 million units

$$\begin{aligned} A &= 3(10)(A/P, 10\%, 10) \\ &= 30(0.16275) \\ &= \$4.8825 \quad (\approx \$4.9 \text{ million}) \end{aligned}$$

Answer is (c)

2.65 $75,000 = 20,000(P/A, 10\%, n)$
 $(P/A, 10\%, n) = 3.75$

By interpolation or NPER function, $n = 4.9$ years

Answer is (b)

2.66 $50,000(F/A, 6\%, n) = 650,000$
 $(F/A, 6\%, n) = 13.0000$

By interpolation or NPER function, $n = 9.9$ years

Answer is (d)

2.67 $40,000 = 13,400(P/A, i, 5)$
 $(P/A, i, 5) = 2.9851$

By interpolation or RATE function, $i = 20.0\%$ per year

Answer is (a)

2.68 $P = 26,000(P/A, 10\%, 5) + 2000(P/G, 10\%, 5)$
 $= 26,000(3.7908) + 2000(6.8618)$
 $= \$112,284$

Answer is (b)

2.69 $F = [5000(P/A, 10\%, 20) + 1000(P/G, 10\%, 20)](F/P, 10\%, 20)$
 $= [5000(8.5136) + 1000(55.4069)](6.7275)$
 $= \$659,126$

Answer is (d)

2.70 $A = 300,000 - 30,000(A/G, 10\%, 4)$
 $= 300,000 - 30,000(1.3812)$
 $= \$258,564$

Answer is (b)

$$\begin{aligned}
\mathbf{2.71} \quad F &= \{5000[1 - (1.03/1.10)^{20}]/(0.10 - 0.03)\}(F/P, 10\%, 20) \\
&= \{5000[1 - (1.03/1.10)^{20}]/(0.10 - 0.03)\}(6.7275) \\
&= \$351,528
\end{aligned}$$

Answer is (c)

Solution to Case Study, Chapter 2

There is no definitive answer to case study exercises. The following are examples only.

Time Marches On; So Does the Interest Rate

1. Situation	A	B	C	D
Interest rate	6% per year	6% per year	15% per year	Simple: 780% per year Comp'd: 143,213% per year

$$\begin{aligned} \text{C: } 2 \text{ million} &= 300,000(P/A, i\%, 65) \\ (P/A, i\%, 64) &= 6.666667 \\ i &= 15\% \end{aligned}$$

$$\text{D: } 30/200 = 15\% \text{ per week}$$

$$\text{Simple: } 15\%(52 \text{ weeks}) = 780\% \text{ per year}$$

$$\text{Compound: } (1.15)^{52} - 1 = 143,213\% \text{ per year}$$

2. A: Start -- \$24

$$\text{End -- } F = 24(1.06)^{385} = \$132 \text{ billion}$$

B: Start -- \$2000 per year or \$20,000 total over 10 years

$$\text{End -- } F_{32} = A(F/A, 6\%, 10) = \$26,361.60$$

$$F_{70} = F_{32}(F/P, 6\%, 38) = \$241,320$$

C: Start -- \$2 million

$$\text{End -- } 300,000(65) = \$19.5 \text{ million over 65 years}$$

$$F_{65} = 300,000(F/A, 15\%, 65) = \$17.6 \text{ billion (equivalent)}$$

D: Simple interest

$$\text{Start -- } \$200$$

$$\text{End -- } (0.15)(12)(200) + 200 = \$1760$$

Compound interest

$$\text{Start -- } \$200$$

$$\text{End -- } 200(1.15)^{52} = \$286,627$$

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 3
Combining Factors and Spreadsheet Functions

3.1 $P = 12,000 + 12,000(P/A, 10\%, 9)$
 $= 12,000 + 12,000(5.7590)$
 $= \$81,108$

3.2 $P = 260,000(P/A, 10\%, 3) + 190,000(P/A, 10\%, 2)(P/F, 10\%, 3)$
 $= 260,000(2.4869) + 190,000(1.7355)(0.7513)$
 $= \$894,331$

3.3 (a) $P = -120(P/F, 12\%, 1) - 100(P/F, 12\%, 2) - 40(P/F, 12\%, 3) + 50(P/A, 12\%, 2)(P/F, 12\%, 3)$
 $+ 80(P/A, 12\%, 4)(P/F, 12\%, 5)$
 $= -120(0.8929) - 100(0.7972) - 40(0.7118) + 50(1.6901)(0.7118)$
 $+ 80(3.0373)(0.5674)$
 $= \$-17,320$

(b) Enter cash flows in, say, column A, and use the function = NPV(12%, A2:A10)*1000 to display \$-71,308.

3.4 $P = 22,000(P/A, 8\%, 8)(P/F, 8\%, 2)$
 $= 22,000(5.7466)(0.8573)$
 $= \$108,384$

3.5 $P = 200(P/A, 10\%, 3)(P/F, 10\%, 1) + 90(P/A, 10\%, 3)(P/F, 10\%, 5)$
 $= 200(2.4869)(0.9091) + 90(2.4869)(0.6209)$
 $= \$591.14$

3.6 Discount amount = $1.56 - 1.28 = \$0.28/1000$ g
Savings in cost of water used/year = $[2,000,000,000/1000]0.28 = \$560,000$

$P = 560,000(P/A, 6\%, 20)$
 $= 560,000(11.4699)$
 $= \$6,423,144$

3.7 $P = 105,000 + 350 + 350(P/A, 10\%, 30)$
 $= 105,000 + 350 + 350(9.4269)$
 $= \$108,649$

$$\begin{aligned}
3.8 \quad P &= (20 - 8) + (20 - 8)(P/A, 10\%, 3) + (30 - 12)(P/A, 10\%, 5)(P/F, 10\%, 3) \\
&\quad + (30 - 25)(P/F, 10\%, 9) \\
&= 12 + 12(2.4869) + 18(3.7908)(0.7513) + 5(0.4241) \\
&= \$95,228
\end{aligned}$$

$$\begin{aligned}
3.9 \quad 2,000,000 &= x(P/F, 10\%, 1) + 2x(P/F, 10\%, 2) + 4x(P/F, 10\%, 3) + 8x(P/F, 10\%, 4) \\
2,000,000 &= x(0.9091) + 2x(0.8264) + 4x(0.7513) + 8x(0.6830) \\
11.0311x &= 2,000,000 \\
x &= \$181,306 \quad (\text{first payment})
\end{aligned}$$

$$\begin{aligned}
3.10 \quad A &= 300,000 + (465,000 - 300,000)(F/A, 10\%, 5)(A/F, 10\%, 9) \\
&= 300,000 + 165,000(6.1051)(0.07364) \\
&= \$374,181 \text{ per year}
\end{aligned}$$

$$\begin{aligned}
3.11 \quad (a) \quad 2,000,000 &= 25,000(F/P, 10\%, 20) + A(F/A, 10\%, 20) \\
2,000,000 &= 25,000(6.7275) + A(57.2750) \\
A &= \$31,983 \text{ per year}
\end{aligned}$$

(b) Yes. In fact, they will exceed their goal by \$459,188

$$\begin{aligned}
3.12 \quad (a) \quad A &= 16,000(A/P, 10\%, 5) + 52,000 + (58,000 - 52,000)(P/F, 10\%, 1)(A/P, 10\%, 5) \\
&= 16,000(0.26380) + 52,000 + 6000(0.9091)(0.26380) \\
&= \$57,660 \text{ per year}
\end{aligned}$$

$$(b) \text{ Annual savings} = 73,000 - 57,660 = \$15,340 \text{ per year}$$

$$\begin{aligned}
3.13 \quad (a) \quad A &= 8000(A/P, 10\%, 9) + 4000 + (5000 - 4000)(F/A, 10\%, 4)(A/F, 10\%, 9) \\
&= 8000(0.17364) + 4000 + (5000 - 4000)(4.6410)(0.07364) \\
&= \$5731 \text{ per year}
\end{aligned}$$

(b) Enter cash flows in, say, column B, rows 2 through 11, and use the embedded function = -PMT(10%,9,NPV(10%,B3:B11) + B2) to display \$5731.

$$\begin{aligned}
3.14 \quad (a) \quad 300 &= 200(A/P, 10\%, 7) + 200(P/A, 10\%, 3)(A/P, 10\%, 7) + x(P/F, 10\%, 4)(A/P, 10\%, 7) \\
&\quad + 200(F/A, 10\%, 3)(A/F, 10\%, 7) \\
300 &= 200(0.20541) + 200(2.4869)(0.20541) + x(0.6830)(0.20541) \\
&\quad + 200(3.3100)(0.10541) \\
0.14030x &= 300 - 213.03 \\
x &= \$619.88
\end{aligned}$$

(b) Enter cash flows in B3 through B9 with a number like 1 in year 4. Now, set up PMT function such as = -PMT(10%,7,NPV(10%,B3:B9) + B2). Use Goal Seek to change year 4 such that PMT function displays 300. Solution is $x = \$619.97$.

$$\begin{aligned}
\text{3.15 Amount owed after first payment} &= 10,000,000(F/P, 9\%, 1) - 2,000,000 \\
&= 10,000,000(1.0900) - 2,000,000 \\
&= \$8,900,000
\end{aligned}$$

$$\begin{aligned}
\text{Payment in years 2 - 5: } A &= 8,900,000(A/P, 9\%, 4) \\
&= 8,900,000(0.30867) \\
&= \$2,747,163 \text{ per year}
\end{aligned}$$

$$\begin{aligned}
\text{3.16 } A &= [6000(P/F, 10\%, 1) + 9000(P/F, 10\%, 3) + 10,000(P/F, 10\%, 6)](A/P, 10\%, 7) \\
&= [6000(0.9091) + 9000(0.7513) + 10,000(0.5645)](0.20541) \\
&= \$3669 \text{ per year}
\end{aligned}$$

3.17 Find P_0 and then convert to A . In \$1000 units,

$$\begin{aligned}
P_0 &= 20(P/A, 12\%, 4) + 60(P/A, 12\%, 5)(P/F, 12\%, 4) \\
&= 20(3.0373) + 60(3.6048)(0.6355) \\
&= \$198.197 \quad (\$198,197)
\end{aligned}$$

$$\begin{aligned}
A &= 198.197(A/P, 12\%, 9) \\
&= 198.197(0.18768) \\
&= \$37.197 \quad (\$39,197 \text{ per year})
\end{aligned}$$

$$\begin{aligned}
\text{3.18 } A &= -2500(A/P, 10\%, 10) + (700 - 200)(P/A, 10\%, 4)(A/P, 10\%, 10) \\
&\quad + (2000 - 300)(F/A, 10\%, 6)(A/F, 10\%, 10) \\
&= -2500(0.16275) + 500(3.1699)(0.16275) + 1700(7.7156)(0.06275) \\
&= \$674.14 \text{ per year}
\end{aligned}$$

$$\begin{aligned}
\text{3.19 } A &= 1000 + [100,000 + 50,000(P/A, 10\%, 5)](A/P, 10\%, 20) \\
&= 1000 + [100,000 + 50,000(3.7908)](0.11746) \\
&= \$35,009 \text{ per year}
\end{aligned}$$

3.20 Payment amount is an A for 10 years in years 0 through 9.

$$\begin{aligned}
\text{Annual amount} &= 150,000(P/F, 10\%, 1)(A/P, 10\%, 10) + 2(300) \\
&= 150,000(0.9091)(0.16275) + 600 \\
&= 22,193 + 600 \\
&= \$22,793 \text{ per year}
\end{aligned}$$

$$\begin{aligned}
\text{3.21 } 360,000 &= 55,000(F/P, 8\%, 5) + 90,000(F/P, 8\%, 3) + A(F/A, 8\%, 3) \\
360,000 &= 55,000(1.4693) + 90,000(1.2597) + A(3.2464) \\
3.2464A &= 165,816 \\
A &= \$51,076 \text{ per year}
\end{aligned}$$

$$\begin{aligned}
\text{3.22 } F &= [100(F/A, 10\%, 7) + (300 - 100)(F/A, 10\%, 2)](F/P, 10\%, 2) \\
&= [100(9.4872) + (300 - 100)(2.1000)](1.2100) \\
&= \$1656.15
\end{aligned}$$

$$\begin{aligned}
3.23 \quad 10A_0 &= A_0 + A_0(F/A, 7\%, n) \\
9A_0 &= A_0(F/A, 7\%, n) \\
(F/A, 7\%, n) &= 9.0000
\end{aligned}$$

Interpolate in 7% table or use function = NPER(7%, -1, 10) to find $n = 7.8 \approx 8$ years.

$$\begin{aligned}
3.24 \quad F &= 70,000(F/P, 10\%, 5) + 20,000(P/A, 10\%, 3)(F/P, 10\%, 5) \\
&= 70,000(1.6105) + 20,000(2.4869)(1.6105) \\
&= \$192,838
\end{aligned}$$

3.25 (a) First calculate P and then convert to F.

$$\begin{aligned}
P_2 &= 540,000(P/A, 10\%, 8) + 6000(P/G, 10\%, 8) \\
&= 540,000(5.3349) + 6000(16.0287) \\
&= \$2,977,018
\end{aligned}$$

$$\begin{aligned}
F &= 2,977,018(F/P, 10\%, 8) \\
&= 2,977,018(2.1436) \\
&= \$6,381,536
\end{aligned}$$

$$\begin{aligned}
(b) F_{\text{cost}} &= -4,000,000(F/P, 10\%, 9) - 5,000,000(F/P, 10\%, 8) \\
&= -4,000,000(2.3579) - 5,000,000(2.1436) \\
&= \$-20,149,600
\end{aligned}$$

$$\text{Difference} = -20,149,600 + 6,381,536 = \$-13,768,064$$

Therefore, cost is not justified by the savings. In fact, it is not even close to being justified.

3.26 Move all cash flows to year 8 and set equal to \$500. Then solve for x.

$$\begin{aligned}
-40(F/A, 10\%, 4)(F/P, 10\%, 4) - W(F/P, 10\%, 3) - 40(F/A, 10\%, 3) &= -500 \\
-40(4.6410)(1.4641) - W(1.3310) - 40(3.3100) &= -500 \\
W &= \$71.98
\end{aligned}$$

$$\begin{aligned}
3.27 \quad -70,000 &= -x(F/A, 10\%, 5)(F/P, 10\%, 3) - 2x(F/A, 10\%, 3) \\
-70,000 &= -x(6.1051)(1.3310) - 2x(3.3100) \\
-70,000 &= -8.1258x - 6.62x \\
-14.7458x &= -70,000 \\
x &= \$4747
\end{aligned}$$

$$\begin{aligned}
3.28 \quad A &= 50,000(A/F, 15\%, 4) \\
&= 50,000(0.20027) \\
&= \$10,015
\end{aligned}$$

3.29 Find F in year 5, subtract future worth of \$42,000, and then use A/F factor.

$$\begin{aligned} F &= 74,000(F/A, 10\%, 5) - 42,000(F/P, 10\%, 4) \\ &= 74,000(6.1051) - 42,000(1.4641) \\ &= \$390,285 \end{aligned}$$

$$\begin{aligned} A &= 390,285(A/F, 10\%, 4) \\ &= 390,285(0.21547) \\ &= \$84,095 \text{ per year} \end{aligned}$$

3.30 $A = 40,000(F/A, 12\%, 3)(A/P, 12\%, 5)$
 $= 40,000(3.3744)(0.27741)$
 $= \$37,444$

3.31 $Q_4 = 25(F/A, 10\%, 6) + 25(P/F, 10\%, 1) + 50(P/A, 10\%, 3)(P/F, 10\%, 1)$
 $= 25(7.7156) + 25(0.9091) + 50(2.4869)(0.9091)$
 $= \$328.66$

3.32 (a) Amount, year 9 = $-70,000(F/P, 12\%, 9) - 4000(F/A, 12\%, 6)(F/P, 12\%, 3)$
 $+ 14,000(F/A, 12\%, 3) + 19,000(P/A, 12\%, 7)$
 $= -70,000(2.7731) - 4000(8.1152)(1.4049) + 14,000(3.3744)$
 $+ 19,000(4.5638)$
 $= \$-105,767$

(b) Enter all cash flows in cells B2 through B18 and use the embedded function
 $= -FV(12\%, 9, NPV(12\%, B3:B18) + B2)$ to display \$-105,768.

3.33 $1,600,000 = Z + 2Z(P/F, 10\%, 2) + 3Z(P/A, 10\%, 3)(P/F, 10\%, 2)$
 $1,600,000 = Z + 2Z(0.8264) + 3Z(2.4869)(0.8264)$
 $8.8183Z = 1,600,000$
 $Z = \$181,440$

Payment, year 2: $2Z = \$362,880$

3.34 In \$1 million units,

Amount owed at end of year 4 = $5(F/P, 15\%, 4) - 0.80(1.5)(F/A, 15\%, 3)$
 $= 5(1.7490) - 0.80(1.5)(3.4725)$
 $= \$4.578 \quad (\$4.578 \text{ million})$

Amount of payment, year 5 = $4.578(F/P, 15\%, 1)$
 $= 4.578(1.1500)$
 $= \$5.2647 \quad (\$5,264,700)$

$$3.35 \quad P = -50(P/F, 10\%, 1) - 50(P/A, 10\%, 7)(P/F, 10\%, 1) - 20(P/G, 10\%, 7)(P/F, 10\%, 1) - (170 - 110)(P/F, 10\%, 5)$$

$$= -50(0.9091) - 50(4.8684)(0.9091) - 20(12.7631)(0.9091) - 60(0.6209) \\ = \$-536$$

$$3.36 \quad P = 13(P/A, 12\%, 3) + [13(P/A, 12\%, 7) + 3(P/G, 12\%, 7)](P/F, 12\%, 3) \\ = 13(2.4018) + [13(4.5638) + 3(11.6443)](0.7118) \\ = \$98.32$$

3.37 First find P and then convert to A

$$P = 100,000(P/A, 10\%, 4) + [100,000(P/A, 10\%, 16) + 10,000(P/G, 10\%, 16)](P/F, 10\%, 4) \\ = 100,000(3.1699) + [100,000(7.8237) + 10,000(43.4164)](0.6830) \\ = \$1,147,883$$

$$A = 1,147,883(A/P, 10\%, 20) \\ = 1,147,883(0.11746) \\ = \$134,830$$

$$3.38 \quad P = 90(P/A, 15\%, 2) + [90(P/A, 15\%, 8) - 5(P/G, 15\%, 8)](P/F, 15\%, 2) \\ = 90(1.6257) + [90(4.4873) - 5(12.4807)](0.7561) \\ = \$404.49$$

3.39 (a) *Hand solution*

$$12,475,000(F/P, 15\%, 2) = 250,000(P/A, 15\%, 13) + G(P/G, 15\%, 13) \\ 12,475,000(1.3225) = 250,000(5.5831) + G(23.1352) \\ 16,498,188 - 1,395,775 = 23.1352G \\ 23.1352G = 15,102,413 \\ G = \$652,789$$

(b) *Spreadsheet solution*

	A	B	C	D
1	Year	Income, \$	Gradient, G =	\$ 652,788
2	0			
3	1	0		
4	2	0		\$12,475,000
5	3	250,000		
6	4	902,788		
7	5	1,555,576		
8	6	2,208,365		
9	7	2,861,153		
10	8	3,513,941		
11	9	4,166,729		
12	10	4,819,517		
13	11	5,472,306		
14	12	6,125,094		
15	13	6,777,882		
16	14	7,430,670		
17	15	8,083,458		

Goal Seek

Set cell:

To value:

By changing cell:

OK Cancel

$$\begin{aligned}
\mathbf{3.40} \quad A &= 5000(A/P, 10\%, 9) + 5500 + 500(A/G, 10\%, 9) \\
&= 5000(0.17364) + 5500 + 500(3.3724) \\
&= \$8054
\end{aligned}$$

3.41 (a) In \$1 million units, find P_0 then use F/P factor for 10 years.

$$P_0 = 3.4(P/A, 10\%, 2) + P_g(P/F, 10\%, 2)$$

$$\begin{aligned}
P_g &= 3.4\{1 - [(1 + 0.03)/(1 + 0.10)]^8\}/(0.10 - 0.03) \\
&= 3.4\{1 - 0.59096\}/0.07 \\
&= \$19.8678
\end{aligned}$$

$$\begin{aligned}
P_0 &= 3.4(P/A, 10\%, 2) + 19.8678(P/F, 10\%, 2) \\
&= 3.4(1.7355) + 19.8678(0.8264) \\
&= \$22.3194
\end{aligned}$$

$$\begin{aligned}
F_{10} &= P_0(F/P, 10\%, 10) \\
&= 22.3194(2.5937) \\
&= \$57.8899 \quad (\$57,889,900)
\end{aligned}$$

(b) Enter 3.4 million for years 1, 2 and 3, then multiply each year by 1.03 through year 10. If the values for years 0-10 are in cells B2:B12, use the function
 $= -FV(10\%, 10, , NPV(10\%, B3:B12))$.

$$\begin{aligned}
\mathbf{3.42} \quad P_{g-1} &= 50,000\{1 - [(1 + 0.15)/(1 + 0.10)]^{11}\}/(0.10 - 0.15) \\
&= 50,000\{-0.63063\}/-0.05 \\
&= \$630,630
\end{aligned}$$

$$\begin{aligned}
F &= 630,630(F/P, 10\%, 11) \\
&= 630,630(2.8531) \\
&= \$1,799,250
\end{aligned}$$

$$\mathbf{3.43} \quad P_0 = 7200(P/A, 8\%, 3) + P_g(P/F, 8\%, 3)$$

$$\begin{aligned}
P_g &= 7200\{1 - [(1 + 0.05)/(1 + 0.08)]^6\}/(0.08 - 0.05) \\
&= 7200\{1 - 0.84449\}/0.03 \\
&= \$37,322
\end{aligned}$$

$$\begin{aligned}
P_0 &= 7200(P/A, 8\%, 3) + 37,322(P/F, 8\%, 3) \\
&= 7200(2.5771) + 37,322(0.7938) \\
&= \$48,181
\end{aligned}$$

3.44 Two ways to approach solution: Find P_g in year -1 and the move it forward to year 0; or handle initial \$3 million separately and start gradient in year 1. Using the former method and \$1 million units,

$$\begin{aligned}
P_{g,-1} &= 3\{1 - [(1 + 0.12)/(1 + 0.15)]^{11}\}/(0.15 - 0.12) \\
&= 3\{1 - 0.74769\}/0.03 \\
&= \$25.2309
\end{aligned}$$

$$\begin{aligned}
P_0 &= 25.2309 (F/P, 15\%, 1) \\
&= 25.2309 (1.15) \\
&= \$29.0156 \quad (\$29,015,600)
\end{aligned}$$

$$\begin{aligned}
\mathbf{3.45} \quad P_{g,-1} &= 150,000(6/(1 + 0.10)) \\
&= \$818,182
\end{aligned}$$

$$\begin{aligned}
P_0 &= 818,182(F/P, 10\%, 1) \\
&= 818,182(1.1000) \\
&= \$900,000
\end{aligned}$$

$$\begin{aligned}
\mathbf{3.46} \quad 16,000 &= [8000 + 8000(P/A, 10\%, 4) - G(P/G, 10\%, 4)](P/F, 10\%, 1) \\
16,000 &= [8000 + 8000(3.1699) - G(4.3781)](0.9091) \\
3.9801G &= -16,000 + 30,327 \\
G &= \$3600
\end{aligned}$$

This is a negative gradient series.

$$\begin{aligned}
\mathbf{3.47} \quad A &= 850(A/P, 10\%, 7) + 800 - 50(A/G, 10\%, 7) \\
&= 850(0.20541) + 800 - 50(2.6216) \\
&= \$843.52
\end{aligned}$$

3.48 Find P in year 0, then use A/P factor for 9 years.

$$\begin{aligned}
P &= 1,800,000(P/A, 12\%, 2) + [1,800,000(P/A, 12\%, 7) - 30,000(P/G, 12\%, 7)](P/F, 12\%, 2) \\
&= 1,800,000(1.6901) + [1,800,000(4.5638) - 30,000(11.6443)](0.7972) \\
&= \$9,312,565
\end{aligned}$$

$$\begin{aligned}
A &= 9,312,565(A/P, 12\%, 9) \\
&= 9,312,565(0.18768) \\
&= \$1,747,782 \text{ per year}
\end{aligned}$$

$$\mathbf{3.49} \quad (a) \quad P_0 = 14,000(P/A, 18\%, 3) + P_g (P/F, 18\%, 3)$$

$$\begin{aligned}
\text{where } P_g &= 14,000\{1 - [(1 - 0.05)/(1 + 0.18)]^7\}/(0.18 + 0.05) \\
&= \$47,525
\end{aligned}$$

$$\begin{aligned}
P_0 &= 14,000(2.1743) + 47,525(0.6086) \\
&= \$59,364
\end{aligned}$$

$$\begin{aligned}
 F &= P_0(F/P, 18\%, 10) \\
 &= 59,364(5.2338) \\
 &= \$310,700
 \end{aligned}$$

- (b) Enter \$14,000 for years 1-4 and decrease entries by 5% through year 10 in B3:B12.
Use the embedded function = -FV(18%,10,,NPV(18%,B3:B12)) to display the future worth of \$310,708.

$$\begin{aligned}
 \mathbf{3.50} \quad P_1 &= 470(P/A, 10\%, 6) - 50(P/G, 10\%, 6) + 470(P/F, 10\%, 7) \\
 &= 470(4.3553) - 50(9.6842) + 470(0.5132) \\
 &= \$1803.99
 \end{aligned}$$

$$\begin{aligned}
 F &= 1803.99(F/P, 10\%, 7) \\
 &= 1803.99(1.9487) \\
 &= \$3515
 \end{aligned}$$

3.51 First find P in year 0 and then convert to A.

$$P_0 = 38,000(P/A, 10\%, 2) + P_g(P/F, 10\%, 2)$$

$$\begin{aligned}
 \text{Where } P_g &= 38,000\{1 - [(1 - 0.15)/(1 + 0.10)]^5\}/(0.10 + 0.15) \\
 &= \$110,123
 \end{aligned}$$

$$\begin{aligned}
 P_0 &= 38,000(1.7355) + 110,123(0.8264) \\
 &= \$156,955
 \end{aligned}$$

$$\begin{aligned}
 A &= 156,955(A/P, 10\%, 7) \\
 &= 156,955(0.20541) \\
 &= \$32,240
 \end{aligned}$$

3.52 Find P_g in year -1 and then move to year 10 with F/P factor.

$$\begin{aligned}
 P_{g-1} &= 100,000\{1 - [(1 - 0.12)/(1 + 0.12)]^{11}\}/(0.12 + 0.12) \\
 &= \$387,310
 \end{aligned}$$

$$\begin{aligned}
 F &= 387,310(F/P, 12\%, 11) \\
 &= 387,310(3.4785) \\
 &= \$1,347,259
 \end{aligned}$$

3.53 Answer is (b)

$$\begin{aligned}
 \mathbf{3.54} \quad P_{-1} &= 9000[1 - (1.05/1.08)^{11}]/(0.08 - 0.05) = \$79,939 \\
 P_0 &= 79,939(F/P, 8\%, 1) = \$86,335
 \end{aligned}$$

Answer is (c)

3.55 Answer is (a)

3.56 Answer is (b)

$$\begin{aligned} \mathbf{3.57} \quad P_{14} &= 10,000(P/A, 10\%, 10) \\ &= 10,000(6.1446) \\ &= \$61,446 \end{aligned}$$

$$\begin{aligned} P_3 &= 61,446(P/F, 10\%, 11) \\ &= 61,446(0.3505) \\ &= \$21,537 \end{aligned}$$

Answer is (d)

$$\begin{aligned} \mathbf{3.58} \quad \text{Amount in year 6} &= 50,000(P/F, 8\%, 6) \\ &= 50,000(0.6302) \\ &= \$31,510 \end{aligned}$$

$$\begin{aligned} A &= 31,510(A/F, 8\%, 4) \\ &= 31,510(0.22192) \\ &= \$6993 \text{ per year} \end{aligned}$$

Answer is (a)

$$\begin{aligned} \mathbf{3.59} \quad P &= 11,000 + 600(P/A, 8\%, 6) + 700(P/A, 8\%, 5)(P/F, 8\%, 6) \\ &= 11,000 + 600(4.6229) + 700(3.9927)(0.6302) \\ &= \$15,535 \end{aligned}$$

Answer is (b)

$$\begin{aligned} \mathbf{3.60} \quad A &= 1000(A/P, 10\%, 5) + 1000 + 500(A/F, 10\%, 5) \\ &= 1000(0.26380) + 1000 + 500(0.16380) \\ &= \$1345.70 \end{aligned}$$

Answer is (c)

$$\begin{aligned} \mathbf{3.61} \quad 5000 &= 200 + 300(P/A, 10\%, 8) + 100(P/G, 10\%, 8) + x(P/F, 10\%, 9) \\ 5000 &= 200 + 300(5.3349) + 100(16.0287) + x(0.4241) \\ 0.4241x &= 1596.66 \\ x &= 3764.82 \end{aligned}$$

Answer is (d)

$$\begin{aligned} \mathbf{3.62} \quad A &= 2,000,000(A/F, 10\%, 5) = 2,000,000(0.16380) \\ &= \$327,600 \end{aligned}$$

Answer is (b)

Solution to Case Study, Chapter 3

There are not always definitive answers to case studies. The following are examples only.

Preserving Land for Public Use

Cash flows for purchases at $g = -25\%$ start in year 0 at \$4 million. Cash flows for parks development at $G = \$100,000$ start in year 4 at \$550,000. All cash flow signs are +.

Year	Cash flow	
	Land	Parks
0	\$4,000,000	
1	3,000,000	
2	2,250,000	
3	1,678,000	
4	1,265,625	\$550,000
5	949,219	650,000
6		750,000

1. Find P. In \$1 million units,

$$P = 4 + 3(P/F, 7\%, 1) + \dots + 0.750(P/F, 7\%, 6)$$

$$= \$13.1716 \quad (\$13,171,600)$$

Amount to raise in years 1 and 2:

$$A = (13.1716 - 3.0)(A/P, 7\%, 2)$$

$$= (10.1716)(0.55309)$$

$$= \$5.6258 \quad (\$5,625,800 \text{ per year})$$

2. Find remaining project fund needs in year 3, then find the A for the next 3 years

$$F_3 = (13.1716 - 3.0)(F/P, 7\%, 3)$$

$$= \$12.46019$$

$$A = 12.46019(A/P, 7\%, 3)$$

$$= \$4.748 \quad (\$4,748,000 \text{ per year})$$

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 4
Nominal and Effective Interest Rates

4.1 $t = \text{one year}$; $CP = \text{one month}$; $m = 12$

4.2 $t = \text{one month}$; $CP = \text{one month}$; $m = 1$

4.3 (a) six times (b) six times (c) two times

4.4 (a) one time (b) six times (c) 18 times

4.5 (a) Quarter (b) Semiannual (c) Month (d) Week (e) Continuous

4.6 (a) Nominal; (b) Nominal; (c) Effective; (d) Nominal; (e) Effective; (f) Effective

4.7 1% per month = nominal 12% per year
3% per quarter = nominal 6% per six months
2% per quarter = nominal 8% per year
0.28% per week = nominal 3.36% per quarter
6.1% per six months = nominal 24.4% per two years

4.8 From interest statement, $r = 11.5\%$ per year is a nominal rate

4.9 $i = 8/4 = 2\%$ per quarter

$r = 2(2\%) = 4\%$ per six months

4.10 Hand solution: $i = (1 + 0.14/12)^{12} - 1$
 $= 14.93\%$ per year

Spreadsheet solution: = EFFECT(14%,12) displays 14.93%

4.11 (a) Use Equation [4.4]

$$i = (1 + 0.1587)^{1/4} - 1$$
$$= 0.0375 \text{ or } 3.75\% \text{ per quarter}$$

(b) $r = 0.0375(4)$
 $= 15\%$ per year

(c) The function = NOMINAL(15.87%,4) displays 15%

4.12 $i = (1 + 0.60)^{1/12} - 1$
 $= 0.0399$ or 3.99% per month

4.13 Hand solution: $i = (1 + 0.21/3)^3 - 1$
 $= 0.225$ or 22.5% per year

Spreadsheet solution: =EFFECT(21%,3) displays 22.5%

4.14 8% per 6 months $= 0.08/6 = 0.0133$ per month

$i = (1 + 0.0133)^3 - 1$
 $= 0.0405$ or 4.05% per quarter

4.15 (a) Use equation [4.4] for effective rate per month

$i = (1 + 0.04)^{1/3} - 1$
 $= 0.0132 = 1.32\%$ per month

APR $= 1.32(12) = 15.8\%$ per year

(b) Use Equation [4.3] for effective annual rate

APY $= (1 + 0.158/12)^{12} - 1$
 $= 17.0\%$

4.16 (a) Interest rate per month $= (10/200)(100\%) = 5\%$

$r = (5\%)(12) = 60\%$ per year

(b) $i = (1 + 0.60/12)^{12} - 1$
 $= 0.796$ or 79.6% per year

4.17 $0.21/m = (1 + 0.2271)^{1/m} - 1$

By trial and error, $m = 4$; compounding is quarterly

4.18 (a) Interest rate per week $= (10/100)(100\%) = 10\%$

$r = (10\%)(52) = 520\%$ per year

(b) $i = (1 + 5.20/52)^{52} - 1$
 $= 141.04$ or 14,104% per year

4.19 (a) PP = one month; CP = six months

(b) PP < CP since month is shorter than 6 months

4.20 (a) CP = years (b) CP = quarters (c) CP = months

4.21 i must be an effective rate *per six months* and n must be the number of semi-annual periods

$$\begin{aligned}\mathbf{4.22} \quad F &= 260,000(F/P, 3\%, 12) \\ &= 260,000(1.4258) \\ &= \$370,708\end{aligned}$$

$$\begin{aligned}\mathbf{4.23} \quad P &= 1,700,000(P/F, 1.5\%, 36) \\ &= 1,700,000(0.5851) \\ &= \$994,670\end{aligned}$$

$$\begin{aligned}\mathbf{4.24} \quad P &= 6(190,000)(P/F, 7\%, 4) \\ &= 6(190,000)(0.7629) \\ &= \$869,706\end{aligned}$$

$$\begin{aligned}\mathbf{4.25} \quad F &= 5000(F/P, 2\%, 48) + 7000(F/P, 2\%, 28) \\ &= 5000(2.5871) + 7000(1.7410) \\ &= \$25,123\end{aligned}$$

4.26 In \$1 million units,

$$\begin{aligned}28 &= 12(F/P, 3\%, 16) + x(F/P, 3\%, 12) \\ 28 &= 12(1.6047) + x(1.4258) \\ 1.4258x &= 8.7436 \\ x &= \$6.1324 \quad (\$6,132,400)\end{aligned}$$

$$\begin{aligned}\mathbf{4.27} \quad P &= 21,000(P/F, 5\%, 4) + 24,000(P/F, 5\%, 6) + 10,000(P/F, 5\%, 10) \\ &= 21,000(0.8227) + 24,000(0.7462) + 10,000(0.6139) \\ &= \$41,325\end{aligned}$$

$$\begin{aligned}\mathbf{4.28} \quad P &= 2,000,000(P/A, 4\%, 20) \\ &= 2,000,000(13.5903) \\ &= \$27,180,600\end{aligned}$$

$$\begin{aligned}\mathbf{4.29} \quad A &= 7,000,000(A/P, 6\%, 10) \\ &= 7,000,000(0.13587) \\ &= \$951,090\end{aligned}$$

$$\begin{aligned}\mathbf{4.30} \quad 926 &= A(P/A, 0.75\%, 60) \\ 926 &= A(48.1734) \\ A &= \$19.22\end{aligned}$$

$$\begin{aligned}
4.31 \quad A &= 3,300,000(A/P, 0.5\%, 240) + (200,000,000/1000)0.85 \\
&= 3,300,000(0.00716) + (200,000,000/1000)0.85 \\
&= 23,628 + 170,000 \\
&= \$193,628 \text{ per month}
\end{aligned}$$

4.32 First find savings at end of year 2011; use amount as an annual series for 10 years.

$$\begin{aligned}
\text{Savings at end of year 2011} &= 42,600(F/A, 0.5\%, 5)(F/P, 0.5\%, 3) \\
&= 42,600(5.0503)(1.0151) \\
&= \$218,391
\end{aligned}$$

$$\begin{aligned}
F &= 218,391(F/A, 0.5\%, 10) \\
&= 218,391(10.2280) \\
&= \$2,233,708
\end{aligned}$$

$$\begin{aligned}
4.33 \quad A_{0\%} &= 3199/12 \\
&= \$266.58 \text{ per month}
\end{aligned}$$

$$\begin{aligned}
A_{0.5\%} &= 3199(A/P, 0.5\%, 12) \\
&= 3199(0.08607) \\
&= \$275.34 \text{ per month}
\end{aligned}$$

$$\begin{aligned}
\text{Savings} &= 275.34 - 266.58 \\
&= \$8.76 \text{ per month}
\end{aligned}$$

$$\begin{aligned}
4.34 \quad A &= 28(F/A, 1.5\%, 24)(A/P, 1.5\%, 240) \\
&= 28(28.6335)(0.01543) \\
&= \$12.3708 \text{ million per month}
\end{aligned}$$

$$4.35 \quad (a) \text{ Interest in payment} = 5000(0.02) = \$100$$

$$\begin{aligned}
(b) \quad 5000 &= 110.25(P/A, 2\%, n) \\
(P/A, 2\%, n) &= 45.3515
\end{aligned}$$

From 2% interest table, $n \approx 120$ months or 10 years

4.36 (a) Find the effective interest rate per month and calculate F after 12 months.

$$\text{Interest rate per month} = (75/500)(100\%) = 15\%$$

$$\begin{aligned}
F &= P(F/P, 15\%, 12) \\
&= 500(5.3503) \\
&= \$2675
\end{aligned}$$

$$\begin{aligned}
(b) \text{ effective } i &= (1 + 0.15)^{12} - 1 \\
&= 4.35 \text{ or } 435\% \text{ per year}
\end{aligned}$$

$$\begin{aligned}
4.37 \quad 300 &= A(P/A, 1.5\%, 12) + [375 - 10(12)](P/F, 1.5\%, 12) \\
300 &= A(10.9075) + [255](0.8364) \\
10.9075A &= 86.72 \\
A &= \$7.95 \text{ per month}
\end{aligned}$$

$$\begin{aligned}
4.38 \quad F &= 285,000(F/P, 2\%, 60) \\
&= 285,000(3.2810) \\
&= \$935,085
\end{aligned}$$

$$\begin{aligned}
4.39 \quad F &= 3,600,000(F/P, 6\%, 16) \\
&= 3,600,000(2.5404) \\
&= \$9,145,440
\end{aligned}$$

4.40 First find F in year 5, then convert to A in years 1 through 5 using the effective annual i .

$$\begin{aligned}
F &= 200,000(F/P, 1.5\%, 48) + 350,000(F/P, 1.5\%, 24) + 400,000 \\
&= 200,000(2.0435) + 350,000(1.4295) + 400,000 \\
&= \$1,309,025
\end{aligned}$$

$$\begin{aligned}
i &= (1 + 0.18/12)^{12} - 1 \\
&= 19.56\% \text{ per year}
\end{aligned}$$

$$A = 1,309,025(A/F, 19.56\%, 5)$$

Solve for A by interpolation between 18% and 20%, by formula, or use spreadsheet function. By spreadsheet function = PMT(19.56%, 5, -1309025)

$$A = \$177,435 \text{ per year}$$

$$\begin{aligned}
4.41 \quad i &= (1 + 0.12/12)^{12} - 1 \\
&= 12.68\% \text{ per year}
\end{aligned}$$

$$F = 30(F/A, 12.68\%, 9) + 20(F/A, 12.68\%, 3)$$

Find factor values by interpolation, formula, or spreadsheet. Figure 2-9 shows spreadsheet functions.

$$\begin{aligned}
F &= 30(15.2077) + 20(3.3965) \\
&= \$524.16
\end{aligned}$$

$$\begin{aligned}
4.42 \quad A &= 480 + 20(A/G, 0.25\%, 120) \\
&= 480 + 20(56.5084) \\
&= \$1,610,168,000 \text{ per month}
\end{aligned}$$

4.43 $i = (1 + 0.10/4)^4 - 1 = 10.38\%$ per year

$$\begin{aligned} P_g &= 100,000\{1 - [(1 + 0.04)/(1 + 0.1038)]^5\}/(0.1038 - 0.04) \\ &= 100,000(4.03556) \\ &= \$403,556 \end{aligned}$$

4.44 A per quarter = 3(1000) = \$3000

$$\begin{aligned} F &= 3000(F/A, 1.5\%, 20) \\ &= 3000(23.1237) \\ &= \$69,371 \end{aligned}$$

4.45 Chemical cost = 11(30) = \$3300 per month

$$\begin{aligned} A &= 2(950)(A/P, 1\%, 36) + 3300 \\ &= 2(950)(0.03321) + 3300 \\ &= \$3363.10 \text{ per month} \end{aligned}$$

4.46 A = 3000(3) = \$9000 per quarter

$$\begin{aligned} F &= 9000(F/A, 1.5\%, 10) \\ &= 9000(10.7027) \\ &= \$96,324 \end{aligned}$$

4.47 A per 6 months = 900(6) = \$5400 semiannually

$$\begin{aligned} P &= 5400(P/A, 7\%, 6) \\ &= 5400(4.7665) \\ &= \$25,739 \end{aligned}$$

4.48 Hand: $r = 0.012(12) = 0.144$ per year

$$\begin{aligned} i &= e^{0.144} - 1 \\ &= 15.49\% \text{ per year} \end{aligned}$$

Spreadsheet: = EFFECT(14.4%, 10000) displays 15.49%

4.49 $r = (0.016)(3) = 0.048\%$ per quarter

$$\begin{aligned} i &= e^{0.048} - 1 \\ &= 4.92\% \text{ per quarter} \end{aligned}$$

4.50 $0.013 = e^r - 1$
 $e^r = 1.013$
 $r = \ln 1.013$
 $= 0.0129$ or 1.29% per month

$$\begin{aligned}
4.51 \quad & 0.25 = e^r - 1 \\
& e^r = 1.25 \\
& r = \ln 1.25 \\
& = 0.22.31 \text{ or } 22.31\% \text{ per year}
\end{aligned}$$

Nominal daily $i = 22.31/365 = 0.061\%$ per day

$$\begin{aligned}
4.52 \quad & i = e^{0.12} - 1 \\
& = 0.1275 \text{ or } 12.75\% \text{ per year}
\end{aligned}$$

$$P = 13,000,000(P/F, 12.75\%, 2)$$

Find factor value by interpolation, formula, or spreadsheet.

$$\begin{aligned}
P &= 13,000,000(0.7866) \\
&= \$10,226,105
\end{aligned}$$

$$\begin{aligned}
4.53 \quad & i = e^{0.10} - 1 \\
& = 0.10517 \text{ or } 10.517\% \text{ per year}
\end{aligned}$$

$$P = 150,000 + 200,000(P/F, 10.517\%, 1) + 350,000(P/F, 10.517\%, 2)$$

Find factor values by interpolation, formula, or spreadsheet.

$$\begin{aligned}
P &= 150,000 + 200,000(0.9048) + 350,000(0.8187) \\
&= \$617,505
\end{aligned}$$

$$\begin{aligned}
4.54 \quad & F = 300,000(F/P, 1\%, 4)(F/P, 1.25\%, 8) \\
& = 300,000(1.0406)(1.1045) \\
& = \$344,803
\end{aligned}$$

$$\begin{aligned}
4.55 \quad & \text{Hand solution: } F = 140,000(F/A, 8\%, 3)(F/P, 10\%, 2) + 140,000(F/A, 10\%, 2) \\
& = 140,000(3.2464)(1.2100) + 140,000(2.1000) \\
& = \$843,940
\end{aligned}$$

Spreadsheet solution: Use embedded FV functions

$$\begin{aligned}
& = \text{FV}(10\%, 2, \text{FV}(8\%, 3, 140000)) + \text{FV}(10\%, 2, -140000) \\
& \text{to display } \$843,940
\end{aligned}$$

4.56 In \$1 million units

$$\begin{aligned}
P &= 1.7(P/F, 10\%, 1) + 2.1(P/F, 12\%, 1)(P/F, 10\%, 1) + 3.4(P/F, 12\%, 2)(P/F, 10\%, 1) \\
& = 1.7(0.9091) + 2.1(0.8929)(0.9091) + 3.4(0.7972)(0.9091) \\
& = \$5,714,212
\end{aligned}$$

$$\begin{aligned}
4.57 \text{ (a)} \quad P &= 100(P/A, 10\%, 5) + 160(P/A, 14\%, 3)(P/F, 10\%, 5) \\
&= 100(3.7908) + 160(2.3216)(0.6209) \\
&= 100(3.7908) + 160(1.4415) \\
&= \$609.72
\end{aligned}$$

$$\begin{aligned}
\text{(b)} \quad 609.72 &= A(3.7908) + A(1.4415) \\
A &= 609.72/5.2323 \\
&= \$116.53 \text{ per year}
\end{aligned}$$

4.58 Answer is (b)

4.59 Answer is (d)

4.60 Answer is (c)

4.61 Answer is (b)

$$\begin{aligned}
4.62 \quad 0.1268 &= (1 + r/12)^{12} - 1 \\
(1 + r/12)^{12} &= 1.1268 \\
12 * \log (1 + r/12) &= \log 1.1268 \\
12 * \log (1 + r/12) &= 0.05185 \\
\log (1 + r/12) &= 0.00432 \\
(1 + r/12) &= 1.0100 \\
r/12 &= 0.0100 \\
r &= 0.12
\end{aligned}$$

$r = 12\%$ per year, compounded monthly = 1% per month

Answer is (c)

(Note: $r = 12\%$ per year, compounded monthly can be found in Table 4-3.)

$$\begin{aligned}
4.63 \quad i &= (1 + 0.02)^6 - 1 \\
&= 12.62\%
\end{aligned}$$

Answer is (d)

4.64 Answer is (b)

4.65 Answer is (c)

4.66 Answer is (c)

4.67 PP < CP; assume no interperiod compounding

$$\begin{aligned} F &= 1000(F/A, 3\%, 50) \\ &= \$112,796.90 \end{aligned}$$

Answer is (d)

4.68 Answer is (d)

4.69 Answer is (b)

4.70 Answer is (a)

4.71 Answer is (c)

$$\begin{aligned} 4.72 \quad A &= 500,000(A/F, 7\%, 12) \\ &= 500,000(0.05590) \\ &= \$27,950 \text{ per 6 months} \end{aligned}$$

Answer is (c)

Solution to Case Study, Chapter 4

There are not always definitive answers to case studies. The following are examples only.

IS OWNING A HOME A NET GAIN OR NET LOSS OVER TIME?

1. Summary of future worth values if sold at \$363,000:

A: 30-year, fixed rate plus investments, $F_A = \$243,246$ (from text)

B: 15-year, fixed rate plus investments, $F_B = \$246,010$ (worked below)

Rent-don't buy: $F = \$109,199$ (spreadsheet below)

Conclusion: Select the 15-year loan

Plan B analysis: 15-year fixed rate loan

Amount of money required for closing costs:

Down payment (10% of \$330,000)	\$33,000
Up-front fees (origination fee, attorney's fee, survey, filing fee, etc.)	<u>3,000</u>
Total	\$36,000

The amount of the loan is \$297,000 and equivalent monthly principal and interest (P&I) is determined at $5.0\%/12 = 0.4167\%$ per month for $15(12) = 180$ months.

$$A = 297,000(A/P, 0.4167\%, 180) = 297,000(0.00791) \\ \approx \$2350$$

Add the T&I of \$500 for a total monthly payment of

$$\text{Payment}_B = \$2850 \text{ per month}$$

The future worth of plan B is the sum of remainder of the \$40,000 available for the closing costs (F_{1B}); left over money from that available for monthly payments (F_{2B}); and, increase in the house value when it is sold after 10 years (F_{3B}).

$$F_{1B} = \$7278$$

No money is available each month to invest after the mortgage payment of \$2850. Therefore,

$$F_{2B} = \$0$$

Net money from the sale in 10 years (F_{3B}) is the difference in net selling price (\$363,000) and remaining balance on the loan.

$$\begin{aligned}
\text{Loan balance} &= 297,000(F/P, 0.4167\%, 120) - 2350(F/A, 0.4167\%, 120) \\
&= 297,000(1.6471) - 2350(155.2856) \\
&= \$124,268
\end{aligned}$$

$$F_{3B} = 363,000 - 124,268 = \$238,732$$

Total future worth of plan B is:

$$F_B = F_{1B} + F_{2B} + F_{3B} = 7278 + 0 + 238,732 = \$246,010$$

Rent-Don't Buy Plan Analysis

	A	B	C	D
1		Return	6.00%	
2				
3		Invested		Total
4	Year	this year	Interest	invested
5	0	40,000	-	40,000
6	1	2,850	2,400	45,250
7	2	2,850	2,715	50,815
8	3	2,850	3,049	56,714
9	4	2,850	3,403	62,967
10	5	2,850	3,778	69,595
11	6	2,850	4,176	76,620
12	7	2,850	4,597	84,068
13	8	2,850	5,044	91,962
14	9	2,850	5,518	100,329
15	10	2,850	6,020	109,199

2. Summary of future worth values if sold at \$231,000:

A: 30-year, fixed rate plus investments, $F_A = \$111,246$

$$F_{3A} \text{ changes to } 231,000 - 243,386 = \$-12,386 \text{ (must pay purchasers to buy)}$$

Total future worth of plan A is:

$$F_A = F_{1A} + F_{2A} + F_{3A} = 7278 + 116,354 - 12,386 = \$111,246$$

B: 15-year, fixed rate plus investments, $F_B = \$114,010$

$$F_{3B} \text{ changes to } 231,000 - 124,286 = \$106,714$$

Total future worth of plan B is:

$$F_B = F_{1B} + F_{2B} + F_{3B} = 7278 + 0 + 106,714 = \$113,992$$

Rent-don't buy: F = \$109,199 (same as above)

Conclusion: Still select the 15-year loan, but the economic advantage is much less.

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 5
Present Worth Analysis

- 5.1** Mutually exclusive alternatives accomplish the same thing. Therefore, *only one* is to be selected, so they are compared against each other. Independent projects accomplish different things. Therefore, none, one, more than one, or all of them can be selected as they are only compared against the do-nothing alternative.
- 5.2** (a) The do-nothing alternative means that the status-quo should be maintained. That is, If none of the alternatives under consideration are economically attractive, all of them should be rejected.
- (b) Do-nothing is not an option when the alternatives being evaluated are cost alternatives, which means that one of them must be selected.
- 5.3** (a) Number of alternatives = $2^4 = 16$
- (b) Possibilities: DN, W, X, Y, Z, WX, WY, WZ, XY, XZ, YZ, WXY, WXZ, WYZ, XYZ, WXYZ
- 5.4** Revenue alternatives have cash inflows and outflows, while cost alternatives have only costs.
- 5.5** Equal service means that alternatives must provide service for the same period of time, and therefore, end at the same time.
- 5.6** Equal service can be satisfied by using a *specified planning period* or by using the *least common multiple between the lives* of the alternatives.
- 5.7** $PW_{\text{In-house}} = -30 + (14 - 5)(P/A, 10\%, 5) + 2(P/F, 10\%, 5)$
 $= -30 + (14 - 5)(3.7908) + 2(0.6209)$
 $= \$5.359 \quad (\$5,359,000)$
- $PW_{\text{Contract}} = (3.1 - 2)(P/A, 10\%, 5)$
 $= (3.1 - 2)(3.7908)$
 $= \$4.170 \quad (\$4,170,000)$
- Select In-house production.
- 5.8** $PW_A = -42,000 - 28,000(P/A, 10\%, 4)$
 $= -42,000 - 28,000(3.1699)$
 $= \$-130,757$

$$\begin{aligned}
 PW_B &= -51,000 - 17,000(P/A, 10\%, 4) \\
 &= -51,000 - 17,000(3.1699) \\
 &= \$-104,888
 \end{aligned}$$

Select Machine B

$$\begin{aligned}
 \text{5.9 (a) } PW_X &= -15,000 - 9000(P/A, 12\%, 5) + 2000(P/F, 12\%, 5) \\
 &= -15,000 - 9000(3.6048) + 2000(0.5674) \\
 &= \$-46,308
 \end{aligned}$$

$$\begin{aligned}
 PW_Y &= -35,000 - 7000(P/A, 12\%, 5) + 20,000(P/F, 12\%, 5) \\
 &= -35,000 - 7000(3.6048) + 20,000(0.5674) \\
 &= \$-48,886
 \end{aligned}$$

Select Material X

(b) Let first cost of Y be X_Y . Set $PW_Y = -46,308$

$$\begin{aligned}
 -46,308 &= -X_Y - 7000(P/A, 12\%, 5) + 20,000(P/F, 12\%, 5) \\
 &= -X_Y - 7000(3.6048) + 20,000(0.5674) \\
 X_Y &= \$32,422
 \end{aligned}$$

Select Y if first cost is $\leq \$32,422$

5.10 Find P_g for each stock and select higher one.

$$\begin{aligned}
 P_{gA} &= 30,000\{1 - [(1 + 0.06)/(1 + 0.08)]^5\}/(0.08 - 0.06) \\
 &= \$133,839
 \end{aligned}$$

$$\begin{aligned}
 P_{gB} &= 20,000\{1 - [(1 + 0.12)/(1 + 0.08)]^5\}/(0.08 - 0.12) \\
 &= \$99,710
 \end{aligned}$$

Select Class A stock

$$\begin{aligned}
 \text{5.11 } PW_A &= -952,000 - 1,300,000 - 126,000(P/A, 6\%, 50) \\
 &= -952,000 - 1,300,000 - 126,000(15.7619) \\
 &= \$-4,238,000
 \end{aligned}$$

$$\begin{aligned}
 PW_B &= -5(366,000) - 9000(151.18) - 340,000 - 81,500 + 500,000(P/F, 6\%, 5) \\
 &= -3,612,120 + 500,000(0.7473) \\
 &= \$-3,238,470
 \end{aligned}$$

Select Plan B

$$\begin{aligned}
 \mathbf{5.12} \quad PW_{\text{No drains}} &= -1500(P/A, 4\%, 12) \\
 &= -1500(9.3851) \\
 &= \$-14,078
 \end{aligned}$$

$$\begin{aligned}
 PW_{\text{Corrugated}} &= -3(7000) + 4000(P/F, 4\%, 12) \\
 &= -21,000 + 4000(0.6246) \\
 &= \$-18,502
 \end{aligned}$$

Do not install corrugated pipe

$$\begin{aligned}
 \mathbf{5.13} \quad PW_{250} &= -155,000 - 3000(P/A, 10\%, 30) \\
 &= -155,000 - 3000(9.4269) \\
 &= \$-183,281
 \end{aligned}$$

$$PW_{300} = \$-210,000$$

Install the 250 mm pipe

$$\begin{aligned}
 \mathbf{5.14} \quad PW_{\text{Gaseous}} &= -8000 - (650 + 800)(P/A, 10\%, 5) \\
 &= -8000 - (1450)(3.7908) \\
 &= \$-13,497
 \end{aligned}$$

$$\begin{aligned}
 PW_{\text{Dry}} &= - (1000 + 1900)(P/A, 10\%, 5) \\
 &= - (2900)(3.7908) \\
 &= \$-10,993
 \end{aligned}$$

Add dry chlorine

$$\begin{aligned}
 \mathbf{5.15} \quad PW_{\text{Volt}} &= -35,000 + 15,000(P/F, 0.75\%, 60) \\
 &= -35,000 + 15,000(0.6387) \\
 &= \$-25,420
 \end{aligned}$$

$$\begin{aligned}
 PW_{\text{Leaf}} &= -1500 - 349(P/A, 0.75\%, 60) \\
 &= -1500 - 349(48.1734) \\
 &= \$-18,313
 \end{aligned}$$

Select the Nissan Leaf

5.16 In \$ million units,

$$\begin{aligned}
 PW_{\text{Land}} &= -215 - 22(P/A, 15\%, 50) - 30(P/F, 15\%, 25) \\
 &= -215 - 22(6.6605) - 30(0.0304) \\
 &= \$-362.443 \quad (\$-362,443,000)
 \end{aligned}$$

$$\begin{aligned}
PW_{\text{Sea}} &= -350 - 2(P/A, 15\%, 50) - 70(P/F, 15\%, 25) \\
&= -350 - 2(6.6605) - 70(0.0304) \\
&= \$-365.449 \quad (\$-365,449,000)
\end{aligned}$$

Select land route by a PW margin of only \$3 million

$$\begin{aligned}
\mathbf{5.17} \quad PW_A &= -40,000[1 + (P/F, 10\%, 2) + (P/F, 10\%, 4) + (P/F, 10\%, 6)] - 9000(P/A, 10\%, 8) \\
&= -40,000 [1 + 0.8264 + 0.6830 + 0.5645] - 9000(5.3349) \\
&= \$-170,970
\end{aligned}$$

$$\begin{aligned}
PW_B &= -80,000[1 + (P/F, 10\%, 4)] - 6000(P/A, 10\%, 8) \\
&= -80,000[1 + 0.6830] - 6000(5.3349) \\
&= \$-166,649
\end{aligned}$$

$$\begin{aligned}
PW_C &= -130,000 - 4000(P/A, 10\%, 8) + 12,000(P/F, 10\%, 8) \\
&= -130,000 - 4000(5.3349) + 12,000(0.4665) \\
&= \$-145,742
\end{aligned}$$

Select Method C

$$\begin{aligned}
\mathbf{5.18} \quad PW_A &= -5,000,000 - 5,500,000(P/A, 10\%, 10) \\
&= -5,000,000 - 5,500,000(6.1446) \\
&= \$-38,795,300
\end{aligned}$$

$$\begin{aligned}
PW_B &= -5,000,000 - 25,000,000(P/F, 10\%, 2) - 30,000,000(P/F, 10\%, 7) \\
&= -5,000,000 - 25,000,000(0.8264) - 30,000,000(0.5132) \\
&= \$-41,056,000
\end{aligned}$$

Select Plan A

$$\begin{aligned}
\mathbf{5.19} \quad (a) \quad PW_X &= -250,000 - 60,000(P/A, 10\%, 6) - 180,000(P/F, 10\%, 3) + 70,000(P/F, 10\%, 6) \\
&= -250,000 - 60,000(4.3553) - 180,000(0.7513) + 70,000(0.5645) \\
&= \$-607,037
\end{aligned}$$

$$\begin{aligned}
PW_Y &= -430,000 - 40,000(P/A, 10\%, 6) + 95,000(P/F, 10\%, 6) \\
&= -430,000 - 40,000(4.3553) + 95,000(0.5645) \\
&= \$-550,585
\end{aligned}$$

Select Machine Y

(b) Spreadsheet solution

	A	B	C
1	Year	X	Y
2	0	-250,000	-430,000
3	1	-60,000	-40,000
4	2	-60,000	-40,000
5	3	-240,000	-40,000
6	4	-60,000	-40,000
7	5	-60,000	-40,000
8	6	10,000	55,000
9	PW @ 10%	-\$607,039	-\$550,585
10			
11			
12		= NPV(10%,C3:C8) + C2	
13			
14			Select Y

PE

5.20 Set the PW_S relation equal to \$-33.16, and solve for the first cost X_S (a positive number) with repurchase in year 5. In \$1 million units,

$$\begin{aligned}
 -33.16 &= -X_S[1 + (P/F, 12\%, 5)] - 1.94(P/A, 12\%, 10) + 0.05X_S[(P/F, 12\%, 5) \\
 &\quad + (P/F, 12\%, 10)] \\
 &= -1.5674X_S - 1.94(5.6502) + 0.0445X_S
 \end{aligned}$$

$$1.5229X_S = -10.9614 + 33.16$$

$$X_S = \$14.576 \quad (\$14,576,000)$$

Select seawater option for any first cost $\leq \$14.576$ million

5.21 $PW_1 = -26,000 - 5000(P/A, 10\%, 6) - 26,000(P/F, 10\%, 3)$
 $= -26,000 - 5000(4.3553) - 26,000(0.7513)$
 $= \$-67,310$

$$\begin{aligned}
 PW_2 &= -83,000 - 1400(P/A, 10\%, 6) - 2500(P/F, 10\%, 3) \\
 &= -83,000 - 1400(4.3553) - 2500(0.7513) \\
 &= \$-90,976
 \end{aligned}$$

Select Plan 1

5.22 Compare PW of costs over 30 years.

$$\begin{aligned}
 PW_{\text{Plastic}} &= -(0.90)(110)(43,560) - [(0.90)(110)(43,560) + 500,000](P/F, 8\%, 15) \\
 &= -4,312,440 - [4,312,440 + 500,000](0.3152) \\
 &= \$-5,829,321
 \end{aligned}$$

$$\begin{aligned}
 PW_{\text{Rubberized}} &= -(2.20)(110)(43,560) \\
 &= \$-10,541,520
 \end{aligned}$$

Select plastic liner

$$\begin{aligned}
 5.23 \text{ (a) } PW_{\text{Fan X}} &= -130,000 - 290(P/A, 8\%, 50) \\
 &= -130,000 - 290(12.2335) \\
 &= \$-133,548
 \end{aligned}$$

$$\begin{aligned}
 PW_{\text{Fan Y}} &= -290(P/A, 8\%, 50) - 20(P/G, 8\%, 50) \\
 &= -290(12.2335) - 20(139.5928) \\
 &= \$-6,340
 \end{aligned}$$

Fan Y made the far better deal (unless fan X's *seats are much better!!*)

(b) Let M_X = 'mortgage' cost for fan X for equivalence of plans

$$\begin{aligned}
 -6340 &= -M_X - 290(P/A, 8\%, 50) \\
 M_X &= 6340 - 290(12.2335) \\
 &= \$2792
 \end{aligned}$$

Fan X should pay only \$2792, not \$130,000

$$\begin{aligned}
 5.24 \text{ (a) } PW_{\text{Land}} &= -130,000 - 95,000(P/A, 10\%, 6) - 105,000(P/F, 10\%, 3) + 25,000(P/F, 10\%, 6) \\
 &= -130,000 - 95,000(4.3553) - 105,000(0.7513) + 25,000(0.5645) \\
 &= \$-608,528
 \end{aligned}$$

$$\begin{aligned}
 PW_{\text{Incin}} &= -900,000 - 60,000(P/A, 10\%, 6) + 300,000(P/F, 10\%, 6) \\
 &= -900,000 - 60,000(4.3553) + 300,000(0.5645) \\
 &= \$-991,968
 \end{aligned}$$

$$\begin{aligned}
 PW_{\text{Contract}} &= -120,000(P/A, 10\%, 6) \\
 &= -120,000(4.3553) \\
 &= \$-522,636
 \end{aligned}$$

Select private disposal contract

(b) Recalculate PW for the contract alternative with 20% increases each 2 years.

$$\begin{aligned}
 PW_{\text{Contract}} &= -120,000(P/A, 10\%, 2) - 120,000(1.20)(P/A, 10\%, 2)(P/F, 10\%, 2) \\
 &\quad - 120,000(1.2)^2(P/A, 10\%, 2)(P/F, 10\%, 4) \\
 &= -120,000(1.7355) - 144,000(1.7355)(0.8264) - 172,800(1.7355)(0.6830) \\
 &= \$-619,615
 \end{aligned}$$

Select land application; the selection changed

5.25 (a) Use LCM of 12 years and select L.

(b) Use PW over life of each alternative and select I, J and L with $PW > 0$.

$$\begin{aligned}
5.26 \quad FW_X &= -80,000(F/P, 15\%, 3) - 30,000(F/A, 15\%, 3) + 40,000 \\
&= -80,000(1.5209) - 30,000(3.4725) + 40,000 \\
&= \$-185,847
\end{aligned}$$

$$\begin{aligned}
FW_Y &= -97,000(F/P, 15\%, 3) - 27,000(F/A, 15\%, 3) + 50,000 \\
&= -97,000(1.5209) - 27,000(3.4725) + 50,000 \\
&= \$-191,285
\end{aligned}$$

Select robot X

$$\begin{aligned}
5.27 \quad FW_T &= -750,000(F/P, 12\%, 4) - 60,000(F/A, 12\%, 4) - 670,000(F/P, 12\%, 2) + 80,000 \\
&= -750,000(1.5735) - 60,000(4.7793) - 670,000(1.2544) + 80,000 \\
&= \$-2,227,331
\end{aligned}$$

$$\begin{aligned}
FW_W &= -1,350,000(F/P, 12\%, 4) - 25,000(F/A, 12\%, 4) - 90,000(F/P, 12\%, 2) + 120,000 \\
&= -1,350,000(1.5735) - 25,000(4.7793) - 90,000(1.2544) + 120,000 \\
&= \$-2,236,604
\end{aligned}$$

Select process T, by a small margin of only \$9273 in FW.

$$\begin{aligned}
5.28 \quad FW_P &= -23,000(F/P, 8\%, 6) - 4000(F/A, 8\%, 6) - 20,000(F/P, 8\%, 3) + 3000 \\
&= -23,000(1.5869) - 4000(7.3359) - 20,000(1.2597) + 3000 \\
&= \$-88,036
\end{aligned}$$

$$\begin{aligned}
FW_Q &= -30,000(F/P, 8\%, 6) - 2500(F/A, 8\%, 6) + 1000 \\
&= -30,000(1.5869) - 2500(7.3359) + 1000 \\
&= \$-64,947
\end{aligned}$$

Select alternative Q

$$\begin{aligned}
5.29 \quad FW_K &= -1,600,000(F/P, 12\%, 8) - 70,000(F/A, 12\%, 8) - 1,200,000(F/P, 12\%, 4) + 400,000 \\
&= -1,600,000(2.4760) - 70,000(12.2997) - 1,200,000(1.5735) + 400,000 \\
&= \$-6,310,780
\end{aligned}$$

$$\begin{aligned}
FW_L &= -2,100,000(F/P, 12\%, 8) - 50,000(F/A, 12\%, 8) - 3000(P/G, 12\%, 8)(F/P, 12\%, 8) \\
&= -2,100,000(2.4760) - 50,000(12.2997) - 3000(14.4714)(2.4760) \\
&= \$-5,922,079
\end{aligned}$$

Select system L

$$\begin{aligned}
5.30 \quad FW_{Old} &= -1,300,000(F/P, 10\%, 5) - 100,000,000(F/P, 10\%, 4) \\
&= -1,300,000(1.6105) - 100,000,000(1.4641) \\
&= \$-148,503,650
\end{aligned}$$

$$\begin{aligned}
 FW_{\text{New}} &= -1,300,000(F/P, 10\%, 6) - 100,000,000 \\
 &= -1,300,000(1.7716) - 100,000,000 \\
 &= \$-102,303,080
 \end{aligned}$$

$$\begin{aligned}
 \text{Difference} &= 148,503,650 - 102,303,080 \\
 &= \$46,200,570 \text{ (higher cost for old contract)}
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{5.31} \quad CC &= (-100,000/0.08)(P/F, 8\%, 5) \\
 &= -1,250,000(0.6806) \\
 &= \$-850,750
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{5.32} \quad (a) \quad CC &= -10,000(A/F, 3\%, 5)/0.03 \\
 &= -10,000(0.18835)/0.03 \\
 &= \$-62,783
 \end{aligned}$$

$$\begin{aligned}
 (b) \quad CC &= -10,000(A/F, 8\%, 5)/0.08 \\
 &= -10,000(0.17046)/0.08 \\
 &= \$-21,308
 \end{aligned}$$

(c) When money earns at the lower 3% rate, it is necessary to start with more.

$$\begin{aligned}
 \mathbf{5.33} \quad CC &= -300,000 - 35,000/0.12 - 75,000(A/F, 12\%, 5)/0.12 \\
 &= -300,000 - 291,667 - 75,000(0.15741)/0.12 \\
 &= \$-690,048
 \end{aligned}$$

PE

5.34 Use C to identify the contractor option.

$$(a) \quad CC_C = -5 \text{ million}/0.12 = \$-41.67 \text{ million}$$

Between the three options, select the contractor

(b) Find P_g and A of the geometric gradient ($g = 2\%$), then CC .

$$\begin{aligned}
 P_g &= -5,000,000[1 - (1.02/1.12)^{50}]/(0.12 - 0.02) \\
 &= -5,000,000[9.9069] \\
 &= \$-49.53 \text{ million}
 \end{aligned}$$

$$\begin{aligned}
 A &= P_g(A/P, 12\%, 50) \\
 &= -49.53 \text{ million}(0.12042) \\
 &= \$-5.96 \text{ million per year}
 \end{aligned}$$

$$\begin{aligned}
 CC_C &= A/i = -5.96 \text{ million}/0.12 \\
 &= \$-49.70 \text{ million}
 \end{aligned}$$

Now, select groundwater ($CC_G = \$-48.91$) source by a relatively small margin.

5.35 For M, first find AW and then divide by i to find CC.

$$\begin{aligned}AW_M &= -150,000(A/P, 10\%, 5) - 50,000 + 8000(A/F, 10\%, 5) \\&= -150,000(0.26380) - 50,000 + 8000(0.16380) \\&= \$-88,260\end{aligned}$$

$$\begin{aligned}CC_M &= -88,260/0.10 \\&= \$-882,600\end{aligned}$$

$$\begin{aligned}CC_N &= -800,000 - 12,000/0.10 \\&= \$-920,000\end{aligned}$$

Select alternative M

$$\begin{aligned}\mathbf{5.36} \quad CC &= -1000/0.10 - 5000(A/F, 10\%, 4)/0.10 \\&= -1000/0.10 - 5000(0.21547)/0.10 \\&= \$-20,774\end{aligned}$$

$$\begin{aligned}\mathbf{5.37} \quad CC &= (-40,000/0.08)(P/F, 8\%, 11) \\&= (-40,000/0.08)(0.4289) \\&= \$-214,450\end{aligned}$$

$$\begin{aligned}\mathbf{5.38} \quad CC &= -150,000 - 5000/0.06 - 20,000(P/F, 6\%, 2) \\&= -150,000 - 5000/0.06 - 20,000(0.8900) \\&= \$-251,133\end{aligned}$$

5.39 Answer is (c)

5.40 Answer is (a)

5.41 Answer is (d)

5.42 Answer is (c)

$$\begin{aligned}\mathbf{5.43} \quad FW_P &= -23,000(F/P, 8\%, 6) - 20,000(F/P, 8\%, 3) - 4,000(F/A, 8\%, 6) + 3000 \\&= -23,000(1.5869) - 20,000(1.2597) - 4,000(7.3359) + 3000 \\&= \$-88,036\end{aligned}$$

Answer is (a)

$$\begin{aligned}\mathbf{5.44} \quad CC &= -50,000 - 10,000(P/A, 10\%, 15) - (20,000/0.10)(P/F, 10\%, 15) \\&= -50,000 - 10,000(7.6061) - (20,000/0.10)(0.2394) \\&= \$-173,941\end{aligned}$$

Answer is (c)

$$\begin{aligned}
 5.45 \quad CC &= (-40,000/0.10)(P/F, 10\%, 4) \\
 &= (-40,000/0.10)(0.6830) \\
 &= \$-273,200
 \end{aligned}$$

Answer is (c)

5.46 Answer is (b)

5.47 Answer is (b)

5.48 Answer is (d)

5.49 Answer is (d)

$$\begin{aligned}
 5.50 \quad PW_Y &= -95,000 - 15,000(P/A, 10\%, 4) + 30,000(P/F, 10\%, 4) \\
 &= -95,000 - 15,000(3.1699) + 30,000(0.6830) \\
 &= \$-122,059
 \end{aligned}$$

Answer is (b)

$$\begin{aligned}
 5.51 \quad CC &= -10,000 - [10,000(A/F, 10\%, 5)]/0.10 \\
 &= -10,000 - [10,000(0.16380)]/0.10 \\
 &= \$-26,380
 \end{aligned}$$

Answer is (c)

$$\begin{aligned}
 5.52 \quad CC &= -10,000 - 5000(P/A, 10\%, 5) - (1000/0.10)(P/F, 10\%, 5) \\
 &= -10,000 - 5000(3.7908) - (1000/0.10)(0.6209) \\
 &= \$-35,163
 \end{aligned}$$

Answer is (b)

Solution to Case Study, Chapter 5

There is not always a definitive answer to case study exercises. Here are example responses

COMPARING SOCIAL SECURITY BENEFITS

1. Total payments are shown in row 30 of the spreadsheet.
2. Future worth values at 6% per year are shown in row 29.

	A	B	C	D	E	F	G	H	I	J
1	Rate =	6.00%	Plan A		Plan B		Plan C		Plan D	
2		Remaining		Future worth		Future worth		Future worth		Future worth
3	Age	Years	Reduced	Reduced	Full	Full	Self-Delayed	Self- Delayed	Spouse-Delayed	Spouse-Delayed
4	61	25								
5	62	24	16,800	16,800					0	
6	63	23	16,800	34,608					0	
7	64	22	16,800	53,484					0	
8	65	21	16,800	73,494					0	
9	66	20	16,800	94,703					0	
10	67	19	16,800	117,185	24,000	24,000			12,000	12,000
11	68	18	16,800	141,016	24,000	49,440			12,000	24,720
12	69	17	16,800	166,277	24,000	76,406			12,000	38,203
13	70	16	16,800	193,054	24,000	104,991	29,760	29,760	29,760	70,255
14	71	15	16,800	221,437	24,000	135,290	29,760	61,306	29,760	104,231
15	72	14	16,800	251,524	24,000	167,408	29,760	94,744	29,760	140,245
16	73	13	16,800	283,415	24,000	201,452	29,760	130,189	29,760	178,419
17	74	12	16,800	317,220	24,000	237,539	29,760	167,760	29,760	218,884
18	75	11	16,800	353,053	24,000	275,792	29,760	207,585	29,760	261,777
19	76	10	16,800	391,036	24,000	316,339	29,760	249,801	29,760	307,244
20	77	9	16,800	431,298	24,000	359,319	29,760	294,549	29,760	355,439
21	78	8	16,800	473,976	24,000	404,879	29,760	341,982	29,760	406,525
22	79	7	16,800	519,215	24,000	453,171	29,760	392,260	29,760	460,677
23	80	6	16,800	567,168	24,000	504,362	29,760	445,556	29,760	518,077
24	81	5	16,800	617,998	24,000	558,623	29,760	502,049	29,760	578,922
25	82	4	16,800	671,878	24,000	616,141	29,760	561,932	29,760	643,417
26	83	3	16,800	728,990	24,000	677,109	29,760	625,408	29,760	711,782
27	84	2	16,800	789,530	24,000	741,736	29,760	692,693	29,760	784,249
28	85	1	16,800	853,702	24,000	810,240	29,760	764,014	29,760	861,064
29	Total FW		\$ 853,702		\$810,240		\$ 764,014		\$ 861,064	
30	Sum		\$ 403,200		\$456,000		\$ 476,160		\$ 512,160	
31										
32										
33										

Answers to #1

Answers to #2

3. Plots of FW values by year are shown in the (x-y scatter) graph below.



4. Develop all feasible plans for the couple and use the summed FW values to determine which is the largest.

Spouse #1	Spouse #2	FW, \$
A	A	1,707,404
A	B	1,663,942
A	C	1,617,716
B	B	1,620,480
B	C	1,574,254
B	D	1,671,304
C	C	1,528,028

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 6
Annual Worth Analysis

6.1 Multiply by $(A/P, i\%, n)$, where n is equal to the LCM or stated study period.

6.2 Three assumptions in the AW method are:

- (1) The services provided are needed for at least the LCM of the lives of the alternatives involved.
- (2) The selected alternative will be repeated in succeeding life cycles
- (3) All cash flows will be the same in all succeeding life cycles, which means that they will change only by the inflation or deflation rate.

6.3 The AW over one life cycle of each alternative can be used to compare them because their AW values for all succeeding life cycles will have exactly the same value as the first.

6.4 $AW_A = -5000(A/P, 10\%, 3) - 25 + 1000(A/F, 10\%, 3)$
 $= -5000(0.40211) - 25 + 1000(0.30211)$
 $= \$-1733.44$

$$AW_B = -5000(A/P, 10\%, 6) - 25 - 4000(P/F, 10\%, 3)(A/P, 10\%, 6) + 1000(A/F, 10\%, 6)$$
$$= -5000(0.22961) - 25 - 4000(0.7513)(0.22961) + 1000(0.12961)$$
$$= \$-1733.46$$

AW values are the same; slight difference due to round-off

6.5 $AW_4 = -20,000(A/P, 10\%, 4) - 12,000 + 4000(A/F, 10\%, 4)$
 $= -20,000(0.31547) - 12,000 + 4000(0.21547)$
 $= \$-17,448$

$$-17,448 = -20,000(A/P, 10\%, 6) - 12,000 - (20,000 - 4000)(P/F, 10\%, 4)(A/P, 10\%, 6)$$
$$+ S(A/F, 10\%, 6)$$

$$= -20,000(0.22961) - 12,000 - (20,000 - 4000)(0.6830)(0.22961)$$
$$+ S(0.12961)$$

$$(0.12961)S = 1,653.38$$

$$S = \$12,756$$

6.6 $AW = -130,000(A/P, 8\%, 50) - 290$
 $= -130,000(0.08174) - 290$
 $= \$-10,916 \text{ per year}$

6.7 Find PW and convert to AW

$$\begin{aligned}PW &= -13,000 - 13,000(P/A, 8\%, 9) - 290(P/A, 8\%, 50) \\&= -13,000 - 13,000(6.2469) - 290(12.2335) \\&= \$-97,757\end{aligned}$$

$$\begin{aligned}AW &= 97,757(A/P, 8\%, 50) \\&= 97,757(0.08174) \\&= \$-7,991 \text{ per year}\end{aligned}$$

6.8
$$\begin{aligned}AW &= -115,000(A/P, 8\%, 8) - 10,500 - 3600(P/F, 8\%, 4)(A/P, 8\%, 8) + 45,000(A/F, 8\%, 8) \\&= -115,000(0.17401) - 10,500 - 3600(0.7350)(0.17401) + 45,000(0.09401) \\&= \$-26,741 \text{ per year}\end{aligned}$$

6.9
$$\begin{aligned}AW &= -2000(P/F, 8\%, 5)(A/P, 8\%, 8) - 800(A/F, 8\%, 2) \\&= -2000(0.6806)(0.17401) - 800(0.48077) \\&= \$-621 \text{ per year}\end{aligned}$$

6.10 (a)
$$\begin{aligned}CR &= -285,000(A/P, 12\%, 10) + 50,000(A/F, 12\%, 10) \\&= -285,000(0.17698) + 50,000(0.05698) \\&= \$-47,590 \text{ per year}\end{aligned}$$

At revenue of \$52,000 per year, yes, he did

(b)
$$\begin{aligned}AW &= -285,000(A/P, 12\%, 10) + 50,000(A/F, 12\%, 10) + 52,000 - 10,000 \\&\quad - 1000(A/G, 12\%, 10) \\&= -285,000(0.17698) + 50,000(0.05698) + 42,000 - 1000(3.5847) \\&= \$-9,175 \text{ per year}\end{aligned}$$

AW was negative

6.11 (a)
$$\begin{aligned}CR &= -500,000(A/P, 8\%, 20) + (0.9)500,000(A/F, 8\%, 20) \\&= -500,000(0.10185) + 450,000(0.02185) \\&= \$-41,093 \text{ per year}\end{aligned}$$

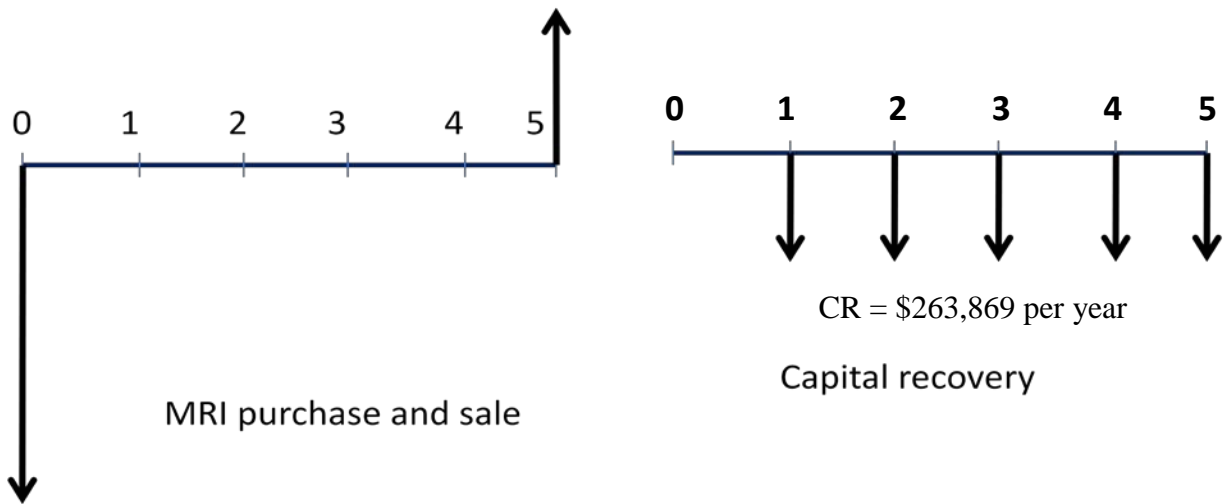
(b)
$$\begin{aligned}41,093 &= 500,000(A/P, 8\%, 10) - S(A/F, 8\%, 10) \\&= 500,000(0.14903) - S(0.06903)\end{aligned}$$

$$\begin{aligned}S &= (74,515 - 41,093)/0.06903 \\&= \$484,166\end{aligned}$$

Sales price must be at least 96.8% of purchase price 10 years earlier.

6.12
$$\begin{aligned}CR &= -750,000(A/P, 24\%, 5) + 75,000(A/F, 24\%, 5) \\&= -750,000(0.36425) + 75,000(0.12425) \\&= \$-263,869 \text{ per year}\end{aligned}$$

Cash flow diagrams are shown here.



$$\begin{aligned}
 6.13 \quad AW_X &= -75,000(A/P, 10\%, 4) - 32,000 + 9000(A/F, 10\%, 4) \\
 &= -75,000(0.31547) - 32,000 + 9000(0.21547) \\
 &= \$-53,721
 \end{aligned}$$

$$\begin{aligned}
 AW_Y &= -140,000(A/P, 10\%, 4) - 24,000 + 19,000(A/F, 10\%, 4) \\
 &= -140,000(0.31547) - 24,000 + 19,000(0.21547) \\
 &= \$-64,072
 \end{aligned}$$

Use Method X

$$\begin{aligned}
 6.14 \quad AW_{Buy} &= [-32,780 - 2200 + 7500 + 0.5(2200)](A/P, 10\%, 3) + 0.40(32,780)(A/F, 10\%, 3) \\
 &= (-26,380)(0.40211) + 13,112(0.30211) \\
 &= \$-6,646
 \end{aligned}$$

$$\begin{aligned}
 AW_{Lease} &= -2500(A/P, 10\%, 3) - 4200 \\
 &= -2500(0.40211) - 4200 \\
 &= \$-5,205
 \end{aligned}$$

The company should lease the car

$$\begin{aligned}
 6.15 \quad AW_{Single} &= -6000(A/P, 10\%, 4) - 6000(P/A, 10\%, 3)(A/P, 10\%, 4) \\
 &= -6000(0.31547) - 6000(2.4869)(0.31547) \\
 &= \$-6,600
 \end{aligned}$$

$$\begin{aligned}
 AW_{Site} &= -22,000(A/P, 10\%, 4) \\
 &= -22,000(0.31547) \\
 &= \$-6,940
 \end{aligned}$$

Buy the single-user license

$$\begin{aligned}
\mathbf{6.16} \quad AW_{\text{permanent}} &= -3,800,000(A/P, 6\%, 20) \\
&= -3,800,000(0.08718) \\
&= \$-331,284
\end{aligned}$$

$$\begin{aligned}
AW_{\text{portable}} &= -22(7500) \\
&= \$-165,000
\end{aligned}$$

The city should lease the restrooms

$$\begin{aligned}
\mathbf{6.17} \quad (a) \quad AW_{\text{Solar}} &= -16,600(A/P, 10\%, 5) - 2400 \\
&= -16,600(0.26380) - 2400 \\
&= \$-6779 \text{ per year}
\end{aligned}$$

$$\begin{aligned}
AW_{\text{Line}} &= -31,000(A/P, 10\%, 5) - 1000 \\
&= -31,000(0.26380) - 1000 \\
&= \$-9178 \text{ per year}
\end{aligned}$$

Use the solar cells

(b) Set $AW_{\text{line}} = -6779$ and solve for first cost P_{line}

$$\begin{aligned}
-6779 &= P_{\text{line}}(A/P, 10\%, 5) - 1000 \\
&= P_{\text{line}}(0.26380) - 1000
\end{aligned}$$

$$P_{\text{line}} = \$21,906$$

$$\begin{aligned}
\mathbf{6.18} \quad AW_{\text{MF}} &= -33,000(A/P, 10\%, 3) - 8000 + 4000(A/F, 10\%, 3) \\
&= -33,000(0.40211) - 8000 + 4000(0.30211) \\
&= \$-20,061
\end{aligned}$$

$$\begin{aligned}
AW_{\text{UF}} &= -51,000(A/P, 10\%, 6) - 3500 + 11,000(A/F, 10\%, 6) \\
&= -51,000(0.22961) - 3500 + 11,000(0.12961) \\
&= \$-13,784
\end{aligned}$$

Select the UF system

$$\begin{aligned}
\mathbf{6.19} \quad (a) \quad AW_{\text{Joe}} &= -85,000(A/P, 8\%, 3) - 30,000 + 40,000(A/F, 8\%, 3) \\
&= -85,000(0.38803) - 30,000 + 40,000(0.30803) \\
&= \$-50,661
\end{aligned}$$

$$\begin{aligned}
AW_{\text{Watch}} &= -125,000(A/P, 8\%, 5) - 27,000 + 33,000(A/F, 8\%, 5) \\
&= -125,000(0.25046) - 27,000 + 33,000(0.17046) \\
&= \$-52,682
\end{aligned}$$

Select robot Joeboy

(b) Spreadsheet and Goal Seek indicate that Watcheye's first cost must be \leq \$-116,935.

	A	B	C
1	Year	Joeboy	Watcheye
2	0	-85,000	-116,935
3	1	-30,000	-27,000
4	2	-30,000	-27,000
5	3	10,000	-27,000
6	4		-27,000
7	5		6,000
8			
9	AW at 8%	-50,662	-50,662

Found using Goal Seek
when cell C9 was set equal
to cell B9 at \$-50,662

$$\begin{aligned}
 6.20 \quad AW_R &= -250,000(A/P, 10\%, 3) - 40,000 + 20,000(A/F, 10\%, 3) \\
 &= -250,000(0.40211) - 40,000 + 20,000(0.30211) \\
 &= \$-134,485
 \end{aligned}$$

$$\begin{aligned}
 AW_S &= -370,500(A/P, 10\%, 5) - 50,000 + 30,000(A/F, 10\%, 5) \\
 &= -370,500(0.26380) - 50,000 + 30,000(0.16380) \\
 &= \$-142,824
 \end{aligned}$$

Select Machine R

$$\begin{aligned}
 6.21 \quad AW_{4 \text{ yrs}} &= -39,000(A/P, 12\%, 4) - [17,000 + 1200(A/G, 12\%, 4)] + 23,000(A/F, 12\%, 4) \\
 &= -39,000(0.32923) - [17,000 + 1200(1.3589)] + 23,000(0.20923) \\
 &= \$-26,658
 \end{aligned}$$

$$\begin{aligned}
 AW_{5 \text{ yrs}} &= -39,000(A/P, 12\%, 5) - [17,000 + 1200(A/G, 12\%, 5)] + 18,000(A/F, 12\%, 5) \\
 &= -39,000(0.27741) - [17,000 + 1200(1.7746)] + 18,000(0.15741) \\
 &= \$-27,115 \text{ per year}
 \end{aligned}$$

Keep the loader for 4 years

$$\begin{aligned}
 6.22 \quad (a) \quad CR_{\text{Semi2}} &= -80,000(A/P, 10\%, 5) + 13,000(A/F, 10\%, 5) \\
 &= -80,000(0.26380) + 13,000(0.16380) \\
 &= \$-18,975 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 CR_{\text{Auto1}} &= -62,000(A/P, 10\%, 5) + 2000(A/F, 10\%, 5) \\
 &= -62,000(0.26380) + 2000(0.16380) \\
 &= \$-16,028 \text{ per year}
 \end{aligned}$$

Capital recovery for Auto1 is lower by \$2947 per year

$$\begin{aligned}
 \text{(b) } AW_{\text{Semi2}} &= -80,000(A/P, 10\%, 5) - [21,000 + 500(A/G, 10\%, 5)] + 13,000(A/F, 10\%, 5) \\
 &= -80,000(0.26380) - [21,000 + 500(1.8101)] + 13,000(0.16380) \\
 &= \$-40,880 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 P_{\text{g-Auto1}} &= -62,000 - 21,000\{1 - [(1 + 0.08)/(1 + 0.10)]^5\}/(0.10 - 0.08) \\
 &\quad + 2000(A/F, 10\%, 5) \\
 &= -62,000 - 21,000\{4.3831\} + 2000(0.16380) \\
 &= \$-153,718
 \end{aligned}$$

$$\begin{aligned}
 AW_{\text{Auto1}} &= -153,718(A/P, 10\%, 5) \\
 &= -153,718(0.26380) \\
 &= \$-40,551 \text{ per year}
 \end{aligned}$$

Select Auto1 by a relatively small margin

$$\begin{aligned}
 \text{6.23 } AW &= -200,000(0.10) - 100,000(A/F, 10\%, 7) \\
 &= -20,000 - 100,000(0.10541) \\
 &= \$-30,541 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 \text{6.24 } AW &= -5M(0.10) - 2M(P/F, 10\%, 10)(0.10) - [(100,000/0.10)(P/F, 10\%, 10)](0.10) \\
 &= -5M(0.10) - 2M(0.3855)(0.10) - [(100,000/0.10)(0.3855)](0.10) \\
 &= \$-615,650 \text{ per year}
 \end{aligned}$$

6.25 First find PW for years 1 through 10 and convert to AW.

$$\begin{aligned}
 PW &= -[150,000(P/A, 10\%, 4) + 25,000(P/G, 10\%, 4)](P/F, 10\%, 2) \\
 &\quad - 225,000(P/A, 10\%, 4)(P/F, 10\%, 6) \\
 &= -[150,000(3.1699) + 25,000(4.3781)](0.8264) \\
 &\quad - 225,000(3.1699)(0.5645) \\
 &= \$-886,009
 \end{aligned}$$

$$\begin{aligned}
 AW &= -886,009(A/P, 10\%, 10) \\
 &= -886,009(0.16275) \\
 &= \$-144,198 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 \text{6.26 } AW_{\text{Condi}} &= -25,000(A/P, 10\%, 3) - 9000 + 3000(A/F, 10\%, 3) \\
 &= -25,000(0.40211) - 9000 + 3000(0.30211) \\
 &= \$-18,146 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 AW_{\text{Torro}} &= -130,000(0.10) - 2500 \\
 &= \$-15,500 \text{ per year}
 \end{aligned}$$

Select the Torro system

$$\begin{aligned}
 6.27 \quad AW &= -30,000,000(0.10) - 50,000 - 1,000,000(A/F, 10\%, 5) \\
 &= -30,000,000(0.10) - 50,000 - 1,000,000(0.16380) \\
 &= \$-3,213,800
 \end{aligned}$$

$$\begin{aligned}
 6.28 \quad (a) \quad AW_X &= -90,000(A/P, 10\%, 3) - 40,000 + 7000(A/F, 10\%, 3) \\
 &= -90,000(0.40211) - 40,000 + 7000(0.30211) \\
 &= \$-74,075
 \end{aligned}$$

$$\begin{aligned}
 AW_Y &= -400,000(A/P, 10\%, 10) - 20,000 + 25,000(A/F, 10\%, 10) \\
 &= -400,000(0.16275) - 20,000 + 25,000(0.06275) \\
 &= \$-83,531
 \end{aligned}$$

$$\begin{aligned}
 AW_Z &= -650,000(0.10) - 13,000 - 80,000(A/F, 10\%, 10) \\
 &= -650,000(0.10) - 13,000 - 80,000(0.06275) \\
 &= \$-83,020
 \end{aligned}$$

Select Alternative X

(b) Goal Seek (right figure, row 2) finds the required first costs for Y = \$-341,912 and Z = \$-560,564 by setting both AW values to $AW_x = \$-74,076$ and solving.

	A	B	C	D
1	Year	X	Y	Z
2	0	-90,000	-400,000	-650,000
3	1	-40,000	-20,000	-13,000
4	2	-40,000	-20,000	-13,000
5	3	-33,000	-20,000	-13,000
6	4		-20,000	-13,000
7	5		-20,000	-13,000
8	6		-20,000	-13,000
9	7		-20,000	-13,000
10	8		-20,000	-13,000
11	9		-20,000	-13,000
12	10		5,000	-93,000
13	AW at 10%	-74,076	-83,530	-83,020
14				
15	AW for infinite life Z:			
16	= -650000*(0.1) -13000 - PMT(10%,10,,-80000)			
17				

	A	B	C	D
1	Year	X	Y	Z
2	0	-90,000	-341,912	-560,564
3	1	-40,000	-20,000	-13,000
4	2	-40,000	-20,000	-13,000
5	3	-33,000	-20,000	-13,000
6	4		-20,000	-13,000
7	5		-20,000	-13,000
8	6		-20,000	-13,000
9	7		-20,000	-13,000
10	8		-20,000	-13,000
11	9		-20,000	-13,000
12	10		5,000	-93,000
13	AW at 10%	-74,076	-74,076	-74,076
14				

6.29 The alternatives are A1, A2, B1, B2 and C. Use a + sign for costs.

$$\begin{aligned}
 AW_{A1} &= \{100,000 + [190,000 + 60,000(P/A, 10\%, 9)](P/F, 10\%, 1)\}(A/P, 10\%, 10) \\
 &= \{100,000 + [190,000 + 60,000(5.7590)](0.9091)\}(0.16275) \\
 &= \$95,511
 \end{aligned}$$

$$\begin{aligned}
 AW_{A2} &= \{200,000 + 190,000(P/A, 10\%, 2) + 55,000(P/A, 10\%, 8)(P/F, 10\%, 2)\}(A/P, 10\%, 10) \\
 &= \{772,227\}(0.16275) \\
 &= \$125,680
 \end{aligned}$$

$$\begin{aligned}
 AW_{B1} &= \{ 50,000 + [215,000 + 45,000(P/A, 10\%, 9)](P/F, 10\%, 1) \}(A/P, 10\%, 10) \\
 &= \{ 481,054 \}(0.16275) \\
 &= \$78,292
 \end{aligned}$$

$$\begin{aligned}
 AW_{B2} &= \{ 100,000 + 265,000(P/A, 10\%, 2) + 30,000(P/A, 10\%, 8)(P/F, 10\%, 2) \}(A/P, 10\%, 10) \\
 &= \{ 692,170 \}(0.16275) \\
 &= \$112,651
 \end{aligned}$$

$$AW_C = \$100,000$$

Select alternative B1

6.30 First find the present worth of all costs and then convert to annual worth over 20 years.

$$\begin{aligned}
 PW &= -6.6 - 3.5(P/F, 7\%, 1) - 2.5(P/F, 7\%, 2) - 9.1(P/F, 7\%, 3) - 18.6(P/F, 7\%, 4) \\
 &\quad - 21.6(P/F, 7\%, 5) - 17(P/A, 7\%, 5)(P/F, 7\%, 5) - 14.2(P/A, 7\%, 10)(P/F, 7\%, 10) \\
 &\quad - 2.7(P/A, 7\%, 3)(P/F, 7\%, 17) \\
 &= -6.6 - 3.5(0.9346) - 2.5(0.8734) - 9.1(0.8163) - 18.6(0.7629) - 21.6(0.7130) \\
 &\quad - 17(4.1002)(0.7130) - 14.2(7.0236)(0.5083) - 2.7(2.6243)(0.3166) \\
 &= \$-151,710,860
 \end{aligned}$$

$$\begin{aligned}
 \text{Annual LCC} &= -151,710,860(A/P, 7\%, 20) \\
 &= -151,710,860(0.09439) \\
 &= \$-14,319,988 \text{ per year}
 \end{aligned}$$

6.31 First find the present worth of all costs and then convert to annual worth over 20 years.

$$\begin{aligned}
 PW &= -2.6(P/F, 6\%, 1) - 2.0(P/F, 6\%, 2) - 7.5(P/F, 6\%, 3) - 10.0(P/F, 6\%, 4) \\
 &\quad - 6.3(P/F, 6\%, 5) - 1.36(P/A, 6\%, 15)(P/F, 6\%, 5) - 3.0(P/F, 6\%, 10) \\
 &\quad - 3.7(P/F, 6\%, 18) \\
 &= -2.6(0.9434) - 2.0(0.8900) - 7.5(0.8396) - 10.0(0.7921) - 6.3(0.7473) \\
 &\quad - 1.36(9.7122)(0.7473) - 3.0(0.5584) - 3.7(0.3503) \\
 &= \$-36,000,921
 \end{aligned}$$

$$\begin{aligned}
 \text{Annual LCC} &= -36,000,921(A/P, 6\%, 20) \\
 &= -36,000,921(0.08718) \\
 &= \$-3,138,560 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 \text{6.32 Annual LCC}_A &= -750,000(A/P, 6\%, 20) - 72,000 - 24,000 \\
 &\quad - 150,000[(P/F, 6\%, 5) + (P/F, 6\%, 10) + (P/F, 6\%, 15)](A/P, 6\%, 20) \\
 &= -750,000(0.08718) - 72,000 - 24,000 \\
 &\quad - 150,000[0.7473 + 0.5584 + 0.4173](0.08718) \\
 &= \$-183,917
 \end{aligned}$$

$$\begin{aligned}
 \text{Annual LCC}_B &= -1,100,000(A/P, 6\%, 20) - 36,000 - 12,000 \\
 &= -1,100,000(0.08718) - 36,000 - 12,000 \\
 &= \$-143,898
 \end{aligned}$$

Select Proposal B

$$\begin{aligned}
 \mathbf{6.33} \quad PW_M &= -250,000 - 150,000(P/A, 8\%, 4) - 45,000 - 35,000(P/A, 8\%, 2) \\
 &\quad - 50,000(P/A, 8\%, 10) - 30,000(P/A, 8\%, 5) \\
 &= -250,000 - 150,000(3.3121) - 45,000 - 35,000(1.7833) \\
 &\quad - 50,000(6.7101) - 30,000(3.9927) \\
 &= \$-1,309,517
 \end{aligned}$$

$$\begin{aligned}
 \text{Annual LCC}_M &= -1,309,517(A/P, 8\%, 10) \\
 &= -1,309,517(0.14903) \\
 &= \$-195,157
 \end{aligned}$$

$$\begin{aligned}
 PW_N &= -10,000 - 45,000 - 30,000(P/A, 8\%, 3) - 80,000(P/A, 8\%, 10) \\
 &\quad - 40,000(P/A, 8\%, 10) \\
 &= -10,000 - 45,000 - 30,000(2.5771) - 80,000(6.7101) - 40,000(6.7101) \\
 &= \$-937,525
 \end{aligned}$$

$$\begin{aligned}
 \text{Annual LCC}_N &= -937,525(A/P, 8\%, 10) \\
 &= -937,525(0.14903) \\
 &= \$-139,719
 \end{aligned}$$

$$\text{Annual LCC}_O = \$-175,000$$

Select Alternative N

6.34 Answer is (a)

6.35 Answer is (d)

6.36 Answer is (a)

6.37 Answer is (b)

6.38 Answer is (d)

6.39 Answer is (b)

$$\begin{aligned}
 \mathbf{6.40} \quad AW_2 &= -550,000(A/P, 6\%, 15) + 100,000 \\
 &= -550,000(0.10296) + 100,000 \\
 &= \$43,372
 \end{aligned}$$

Answer is (b)

6.41 Answer is (c)

6.42 Answer is (d)

6.43 Answer is (b)

6.44 Answer is (a)

$$\begin{aligned}\mathbf{6.45} \quad AW &= -40,000(A/P, 15\%, 4) - 5000 + 32,000(A/F, 15\%, 4) \\ &= -40,000(0.35027) - 5000 + 32,000(0.20027) \\ &= \$-12,602\end{aligned}$$

Answer is (d)

$$\begin{aligned}\mathbf{6.46} \quad AW &= -50,000(0.12) - [(20,000/0.12)](P/F, 12\%, 15)(0.12) \\ &= -50,000(0.12) - [(20,000/0.12)](0.1827)(0.12) \\ &= \$-9654\end{aligned}$$

Answer is (c)

6.47 Answer is (c)

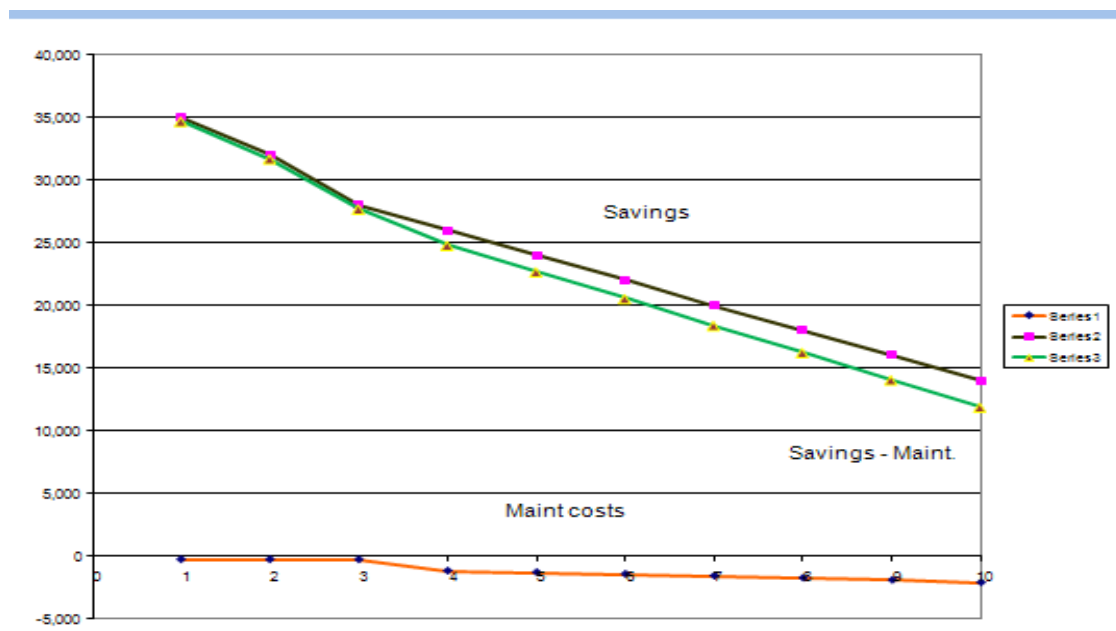
Solution to Case Study, Chapter 6

There is not always a definitive answer to case study exercises. Here are example responses

THE CHANGING SCENE OF AN ANNUAL WORTH ANALYSIS

1. Spreadsheet and chart are below. Revised costs and savings are in columns F-H.

	A	B	C	D	E	F	G	H
1	MARR =	15%						
2								
3			PowrUp			Lloyd's		Lloyd's new
4		Investment	Annual	Repair	Investment	Annual	Repair	maint. cost -
5	Year	and salvage	maint.	savings	and salvage	maint.	savings	repair savings
6	0	-26,000	0	0	-36,000	0	0	
7	1	0	-800	25,000	0	-300	35,000	34,700
8	2	0	-800	25,000	0	-300	32,000	31,700
9	3	0	-800	25,000	0	-300	28,000	27,700
10	4	0	-800	25,000	0	-1,200	26,000	24,800
11	5	0	-800	25,000	0	-1,320	24,000	22,680
12	6	2,000	-800	25,000	0	-1,452	22,000	20,548
13	7				0	-1,597	20,000	18,403
14	8				0	-1,757	18,000	16,243
15	9				0	-1,933	16,000	14,067
16	10				0	-2,126	14,000	11,874
17	AW element	-6,642	-800	25,000	-7,173	-977	26,055	
18	Total AW			\$ 17,558			\$ 17,904	



2. In cell G18, the new $AW = \$17,904$. This is only slightly larger than the PowrUp $AW = \$17,558$. Select Lloyd's, but only by a small margin.
3. New CR is $-\$7173$ (cell E17), an increase from $-\$7025$ previously determined.

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 7
Rate of Return Analysis: One Project

7.1 (a) The return would be -100%, if the entire initial investment were lost with no return.

(b) The return would be infinite if money were received and there was no unrecovered balance.

7.2 *Interest charged on principal:*

$$\text{Interest on principal} = 1,000,000(3)(0.10) = \$300,000$$

Interest charged on unrecovered balance:

$$\begin{aligned}\text{Annual payment} &= 1,000,000(A/P, 10\%, 3) \\ &= 1,000,000(0.40211) \\ &= \$402,110\end{aligned}$$

$$\begin{aligned}\text{Interest, year 1} &= 1,000,000(0.10) \\ &= \mathbf{\$100,000}\end{aligned}$$

$$\begin{aligned}\text{Balance, year 1} &= 1,100,000 - 402,110 \\ &= \$697,890\end{aligned}$$

$$\begin{aligned}\text{Interest, year 2} &= 697,890(0.10) \\ &= \mathbf{\$69,789}\end{aligned}$$

$$\begin{aligned}\text{Balance, year 2} &= 697,890(1.10) - 402,110 \\ &= \$365,569\end{aligned}$$

$$\begin{aligned}\text{Interest, year 3} &= 365,569(0.10) \\ &= \mathbf{\$36,557}\end{aligned}$$

$$\begin{aligned}\text{Total interest paid} &= 100,000 + 69,789 + 36,557 \\ &= \$206,346\end{aligned}$$

$$\begin{aligned}\text{Difference} &= 300,000 - 206,346 \\ &= \$93,654\end{aligned}$$

7.3 $r = 0.08(4) = 32\%$ per year, compounded quarterly

$$\begin{aligned}
7.4 \text{ Amount of each payment} &= 50,000(A/P, 10\%, 5) \\
&= 50,000(0.26380) \\
&= \$13,190
\end{aligned}$$

$$\begin{aligned}
\text{Unrecovered balance after 3}^{\text{rd}} \text{ payment} &= 50,000(F/P, 10\%, 3) - 13,190(F/A, 10\%, 3) \\
&= 50,000(1.3310) - 13,190(3.3100) \\
&= \$22,891
\end{aligned}$$

$$\begin{aligned}
7.5 \text{ (a) Payment} &= 50,000,000/10 + 50,000,000(0.10) \\
&= \$10,000,000 \text{ per year}
\end{aligned}$$

$$\begin{aligned}
\text{(b) Total interest paid} &= [50,000,000(0.10)](10) \\
&= \$50,000,000
\end{aligned}$$

Interest paid is equal to the original amount of the loan.

$$7.6 \text{ Profit} = (24,112,054 - 8,432,372)(0.5) = \$7,839,841$$

$$\begin{aligned}
0 &= -9,000,000 + 7,839,841(P/A, i, 3) \\
(P/A, i, 3) &= 1.1480
\end{aligned}$$

Find i from equation, table, or spreadsheet

$$i = 69.1\% \quad (\text{spreadsheet using RATE function})$$

$$\begin{aligned}
7.7 \quad 0 &= -3.1 + (2)(0.2)(P/A, i, 10) \\
(P/A, i, 10) &= 7.7500
\end{aligned}$$

Find which interest table has 7.7500 in P/A column at $n = 10$

i is between 4% and 5%

$$i = 4.9\% \quad (\text{spreadsheet, equation, or table interpolation})$$

$$\begin{aligned}
7.8 \quad 0 &= -108,000,000 + 59(160,000)(P/A, i\%, 20) \\
(P/A, i\%, 20) &= 108,000,000/9,440,000 = 11.4407
\end{aligned}$$

$$i = 6.03\% \quad (\text{spreadsheet RATE function or interpolation})$$

7.9 *Hand:*

$$0 = -3000 - 200(P/A, i, 3)(P/F, i, 1) - 90(P/A, i, 3)(P/F, i, 5) + 7000(P/F, i, 8)$$

By trial and error and interpolation

$$\begin{aligned}
\text{Try 5\%: } 0 &= -3000 - 200(2.7232)(0.9524) - 90(2.7232)(0.7835) + 7000(0.6768) \\
&= \$1027.10
\end{aligned}$$

$$\begin{aligned}\text{Try } 10\%: 0 &= -3000 - 200(2.4869)(0.9091) - 90(2.4869)(0.6209) + 7000(0.4665) \\ &= \$-325.60\end{aligned}$$

$$i = 5\% + (5) \frac{1027.10}{1352.70} = 5 + 3.79 = 8.79\%$$

Spreadsheet: Enter net cash flows (in cells B2 through B10) and the function
= IRR(B2:B10) to display $i = 8.59\%$

7.10 $0 = -2000 + 7000(P/F, i, 2)$
 $(P/F, i, 2) = 0.28571$

Solve by equation or spreadsheet

$$i = 87.1\% \text{ per year} \quad (\text{RATE on spreadsheet})$$

7.11 $0 = -17,000 + 2500(P/A, i, 5) + 1000(P/G, i, 5) + 3000(P/F, i, 5)$

Solve for i by trial and error or spreadsheet

$$i = 12.2\% \quad (\text{spreadsheet})$$

7.12 $0 = -2900(F/A, i, 9) - 2000 + 40,000$
 $(F/A, i, 9) = 38,000/2900$
 $(F/A, i, 9) = 13.1034$

$$i = 9.2\% \text{ per month} \quad (\text{RATE function on spreadsheet})$$

7.13 $1,064,247 = 1,694,247(P/F, i, 15)$
 $(P/F, i, 15) = 0.62815$

Solve for i by trial and error or spreadsheet

$$i = 3.1\% \text{ per year} \quad (\text{spreadsheet})$$

7.14 $0 = -65,220(P/A, i, 4) + (57,925 - 35,220)(P/A, i, 31)(P/F, i, 4)$
 $0 = -65,220(P/A, i, 4) + (22,705)(P/A, i, 31)(P/F, i, 4)$

Solve by trial and error:

$$\text{Try } 6\%: 0 = -225,994 + 232,460 = \$6466 \quad i \text{ too low}$$

$$\text{Try } 7\%: 0 = -220,914 + 217,070 = -\$3844 \quad i \text{ too high}$$

$$i = 6.85\% \text{ per year} \quad (\text{spreadsheet})$$

7.15 (a) Effective dividend rate = $5.38(1 - 0.35) = 3.5\%$ per year

(b) Dividend savings per year = $53M(0.0538)(0.35) = \$997,990$

Total dividend savings = $997,990(20) = \$19,959,800$

(c) $F = 997,990(F/A, 6\%, 20)$
 $= 997,990(36.7856)$
 $= \$36.7117$ million

7.16 In \$1 million units,

$$0 = -100 - 400(0.1) + 20(P/A, i, 10)$$

$$0 = -140 + 20(P/A, i, 10)$$

$$(P/A, i, 10) = 7.000$$

From 7% and 8% tables, i is slightly over 7%

$i = 7.07\%$ per year (RATE function on spreadsheet)

7.17 Spending \$60,000 now will result in savings of \$28,000 in years 0, 3 and 6.

$$0 = -60,000 + 28,000 + 28,000[(P/F, i, 3) + (P/F, i, +6)]$$

$$0 = -32,000 + 28,000[(P/F, i, 3) + (P/F, i, +6)]$$

Solve for i by trial and error or spreadsheet

$i = 13.7\%$ per year (IRR function on spreadsheet)

7.18 *Hand:* In \$1 million units,

$$0 = -500 + 1.8(0.1)(2500)(P/F, i, 2) + 500(1.8)(0.9)(P/A, i, 5)(P/F, i, 5) - 10(P/A, i, 10)$$

$$0 = -500 + 450(P/F, i, 2) + 810(P/A, i, 5)(P/F, i, 5) - 10(P/A, i, 10)$$

Solve for i by trial and error

$i = 42\%$ per year

Spreadsheet:

	A	B	C	D
1	Year	Expenses	Income	NCF
2	0	-500	0	-500
3	1	-10	0	-10
4	2	-10	450	440
5	3	-10	0	-10
6	4	-10	0	-10
7	5	-10	0	-10
8	6	-10	810	800
9	7	-10	810	800
10	8	-10	810	800
11	9	-10	810	800
12	10	-10	810	800
13	ROR			40.6%

7.19 3 years = 3(52) = 156 weeks

$$0 = -5(6000) + 600(P/A, i, 156)$$

$$(P/A, i, 156) = 50.0000$$

Solve for i by trial and error or spreadsheet

(a) $i = 1.89\%$ per week (RATE function on spreadsheet)

(b) nominal rate = $1.89(52) = 98.3\%$ per year

7.20 Hand: Find the equivalent value of both series in year 10

$$0 = -(4,000,000/10)(F/A, i\%, 10) + 270,000/i$$

Solve for i by trial and error

$$\begin{array}{ll} \text{Try 5\%: } 0 = -400,000(12.5779) + 270,000/0.05 = +368.84 & i \text{ too low} \\ \text{Try 6\%: } 0 = -400,000(13.1808) + 270,000/0.06 = -772.32 & i \text{ too high} \end{array}$$

$i = 5.3\%$ per year

Spreadsheet: This is a good application of the Goal Seek tool. Result is $i = 5.29\%$ per year.

	A	B	C	D	E
1	Year	Expenses	Income	NCF	10.00%
2	0	0	0	0	
3	1	-400	0	-400	
4	2	-400	0	-400	
5	3	-400	0	-400	
6	4	-400	0	-400	
7	5	-400	0	-400	
8	6	-400	0	-400	
9	7	-400	0	-400	
10	8	-400	0	-400	
11	9	-400	0	-400	
12	10	-400	0	-400	
13	11	0	270	270	
14	:	0	270	270	
15	F in year 10			-3674.97	

	A	B	C	D	E
1	Year	Expenses	Income	NCF	5.29%
2	0	0	0	0	
3	1	-400	0	-400	
4	2	-400	0	-400	
5	3	-400	0	-400	
6	4	-400	0	-400	
7	5	-400	0	-400	
8	6	-400	0	-400	
9	7	-400	0	-400	
10	8	-400	0	-400	
11	9	-400	0	-400	
12	10	-400	0	-400	
13	11	0	270	270	
14	:	0	270	270	
15	F in year 10				0.00
16					

Goal Seek

Set cell:

To value:

By changing cell:

OK Cancel

7.21 A nonconventional cash flow series is one wherein the signs on the net cash flows change *more than once*.

7.22 NCF swings indicating multiple ROR roots can occur for:

- Large phase-out costs after a positive NCF series, e.g., environmental cleanup
- Large upgrade or reinvestment in mid-life surrounded by positive NCF series
- Unexpected mid-life expenditure, e.g., one-time repair cost on oil well equipment

7.23 Describe something that had a large, possibly unexpected negative cash flow necessary to get rid of it.

7.24 Descartes' rule of signs states that the total number of real-number roots is equal to or less than the number of sign changes in the net cash flow series.

7.25 (a) Four (b) One (c) Seven

7.26 According to Norstrom's criterion, there is only one positive root in a rate of return equation when the *cumulative cash flows* (1) start out negatively, and (2) there is only one sign change in them.

7.27 The net cash flow changes signs four times, so there are four possible i^* values.

Year	1	2	3	4
NCF, \$	-5000	+6000	-2000	+58,000

Three sign changes, indicating there are three possible i^* values.

7.29 The net cash flow changes sign three times and Norstrom's criterion is no help, so there are three possible i^* values.

Year	0	1	2	3	4
NCF, \$	-6000	-5000	+8000	-2000	+6000
Cum CF, \$	-6000	-11,000	-3000	-5000	1000

Answer is \$1000

(a) Year	0	1	2	3	4	5	6
NCF, \$	-30	-2	-6	+21	+30	+18	+40

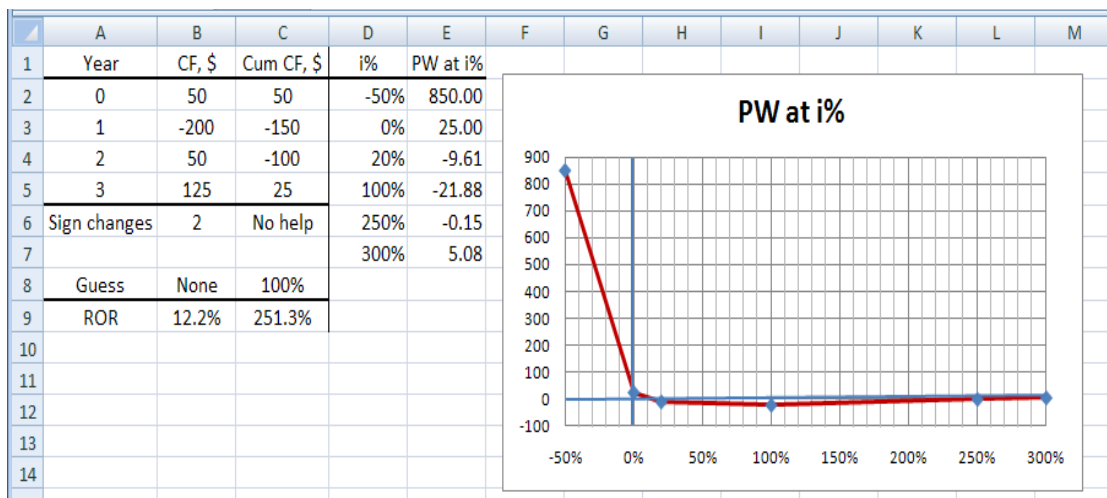
There is only one change in sign in the net cash flow; there is only one i^* value.

$$(b) 0 = -30 - 2(P/F, i, 1) - 6(P/F, i, 2) + 21(P/F, i, 3) + 30(P/F, i, 4) + 18(P/F, i, 5) + 40(P/F, i, 6)$$

Solve for i by trial and error or spreadsheet

$$i^* = 28.3\% \quad (\text{IRR function on spreadsheet})$$

7.32

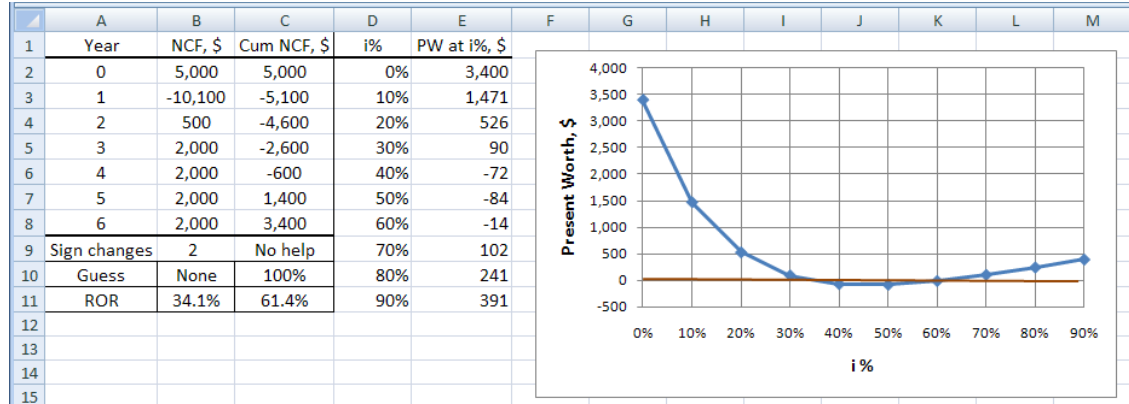


Descartes' rule of signs: 2 sign changes

Norstrom's criterion: series starts positive; no help

There are two positive roots: 12.2% and 251.3%. Since both are positive, neither is valid.

7.33



- (a) Plot shows two rates at approximately 35% and 60%.
- (b) IRR function (row 11) displays 34.1% and 61.4% using guess of 100% to get second value.
- (c) Descartes' rule of signs: 2 sign changes
Norstrom's criterion: series starts positive; no help

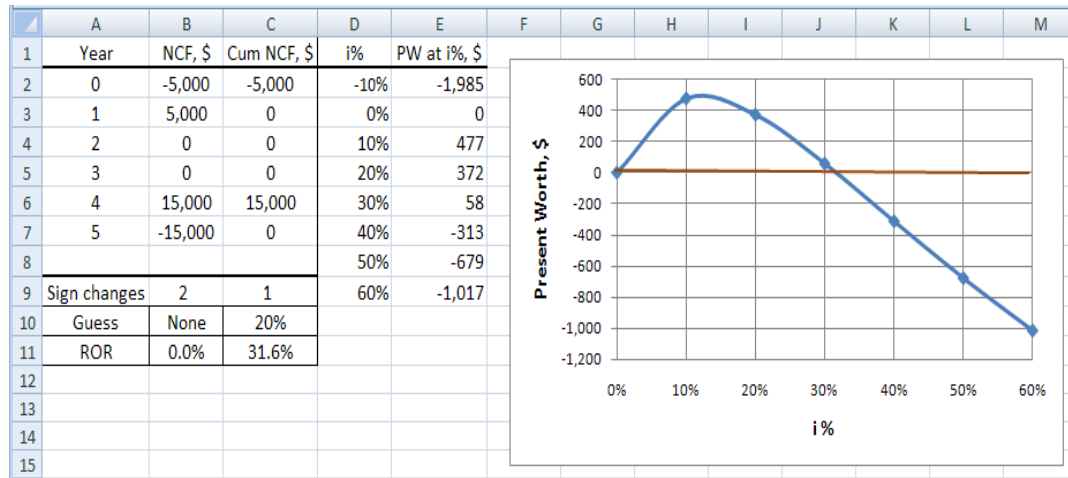
Since both roots are positive, technique of next section is necessary to find one root. However, with MARR = 30%, PW = \$90 (spreadsheet). Therefore, use 34.1% as most reliable at this point.

7.34

	A	B	C	D	E
1	Year	NCF, \$100,000	Cum NCF, \$100,000	i%	PW at i%, \$100,000
2	2005	-25	-25	-25%	-40.62
3	2006	10	-15	-15%	-4.61
4	2007	10	-5	-10%	1.23
5	2008	15	10	-9%	1.91
6	2009	15	25	-8%	2.48
7	2010	-5	20	5%	3.39
8	2011	-6	14	10%	2.25
9	2012	-10	4	15%	0.86
10	Sign changes	2	1	20%	-0.62
11	Guess	-25%	15%	25%	-2.08
12	ROR	-11.4%	17.9%	50%	-8.25

- (a) Descartes' rule of signs: 2 sign changes
Norstrom's criterion; series starts negative; 1 sign change
There is one positive root
- (b) IRR function finds $i^*_1 = -11.4\%$ and $i^*_2 = 17.9\%$. See spreadsheet for PW values.
- (c) Use $i^* = 17.9\%$ as the correct rate.

7.35 Norstrom's criterion predicts one positive root. The rates of 0% and 31.6% are found.



7.36 The investment rate is used when *positive net cash flows* are generated in a project. The borrowing rate is used when *negative net cash flows* are generated in a project.

7.37 The investment rate is usually higher than the borrowing rate because viable companies can invest money at a higher a rate of return than the rate at which they borrow it. If they can't do that, they won't be in business very long.

7.38 Follow the steps of the modified ROR procedure.

$$\begin{aligned}
 PW_0 &= -32,000(P/F, 10\%, 1) - 25,000(P/F, 10\%, 2) \\
 &= -32,000(0.9091) - 25,000(0.8264) \\
 &= \$-49,751
 \end{aligned}$$

$$\begin{aligned}
 FW_3 &= 16,000(F/P, 18\%, 3) + 70,000 \\
 &= 16,000(1.6430) + 70,000 \\
 &= \$96,288
 \end{aligned}$$

$$\begin{aligned}
 96,288 &= 49,751(F/P, i, 3) \\
 (F/P, i, 3) &= 1.9354
 \end{aligned}$$

Use interpolation in factor tables or spreadsheet to find i'

$$i' = 24.6\% \text{ per year} \quad (\text{spreadsheet})$$

7.39 Hand: Follow the steps of the modified ROR procedure.

$$\begin{aligned}
 PW_0 &= -9000 - 2000(P/F, 8\%, 2) - 7000(P/F, 8\%, 3) \\
 &= -9000 - 2000(0.8573) - 7000(0.7938) \\
 &= \$-16,271
 \end{aligned}$$

$$\begin{aligned}
 FW_6 &= 4100(F/P, 15\%, 5) + 12,000(F/P, 15\%, 2) + 700(F/P, 15\%, 1) + 800 \\
 &= 4100(2.0114) + 12,000(1.3225) + 700(1.1500) + 800 \\
 &= \$25,722
 \end{aligned}$$

$$\begin{aligned}
 25,722 &= 16,271(F/P, i, 6) \\
 (F/P, i, 6) &= 1.5808
 \end{aligned}$$

Use interpolation in factor tables or spreadsheet to find i .

$$i' = 7.9\% \text{ per year} \quad (\text{spreadsheet})$$

Spreadsheet function: Enter NCF values (B2:B8) and =MIRR(B2:B8, 8%, 15%) to display 7.9% per year.

7.40 (a) There are three changes in sign on the net cash flow, so there are three possible rate of return values.

$$\begin{aligned}
 (b) \quad PW_0 &= -8000(P/A, 8\%, 6) - 8000(P/A, 8\%, 2)(P/F, 8\%, 7) \\
 &= -8000(4.6229) - 8000(1.7833)(0.5835) \\
 &= \$-45,307
 \end{aligned}$$

$$\begin{aligned}
 FW_{10} &= 52,000(F/P, 12\%, 3) + 20,000 \\
 &= 52,000(1.4049) + 20,000 \\
 &= \$93,055
 \end{aligned}$$

$$\begin{aligned}
 45,307(F/P, i, 10) &= 93,055 \\
 (F/P, i, 10) &= 2.0539
 \end{aligned}$$

Use interpolation in factor tables or spreadsheet to find i'

$$i' = 7.5\% \text{ per year} \quad (\text{spreadsheet})$$

(c) Use the same spreadsheet functions as Figure 7-12 to display the ROIC of $i'' = 3.78\%$.

	A	B	C	D
	Year	NCF, \$	Future worth value, F, \$	
2	0	0	0	
3	1	-8,000	-8,000	
4	2	-8,000	-16,302	= IF(C3<0, C3*(1+\$C\$15)+B4, C3*(1+\$C\$14)+B4)
5	3	-8,000	-24,918	
6	4	-8,000	-33,858	
7	5	-8,000	-43,137	
8	6	-8,000	-52,766	
9	7	52,000	-2,758	
10	8	-8,000	-10,862	
11	9	-8,000	-19,272	
12	10	20,000	0	
13				
14	Investment rate, i_i		12.00%	
15	Goal Seek, ROIC		3.78%	

Set cell:	\$C\$12
To value:	0
By changing cell:	\$C\$15
<input type="button" value="OK"/> <input type="button" value="Cancel"/>	

(d) The IRR function displays $i^* = 3.78\%$. It is the same as $ROIC = 3.78\%$ because the FW value (column C above) never becomes positive; therefore, only the ROIC is used in the IF functions. The ROIC value is independent of the re-investment rate.

7.41 $i_i = 20\%$ and $i_b = 9\%$. Follow the steps of the modified ROR procedure.

$$\begin{aligned}
 PW_0 &= -400,000 - 30,000(P/F, 9\%, 3) \\
 &= -400,000 - 30,000(0.7722) \\
 &= \$-423,166
 \end{aligned}$$

$$\begin{aligned}
 FW_0 &= 160,000(F/A, 20\%, 2)(F/P, 20\%, 8) + 160,000(F/A, 20\%, 7) \\
 &= 160,000(2.2000)(4.2998) + 160,000(12.9159) \\
 &= \$3,580,074
 \end{aligned}$$

$$\begin{aligned}
 0 &= -423,166 + 3,580,074(P/F, i, 10) \\
 (P/F, i, 10) &= 0.1182
 \end{aligned}$$

Solve by formula or spreadsheet

$$i' = 23.8\% \text{ per year} \quad (\text{spreadsheet})$$

- 7.42** (a) Descartes' rule of signs: 2 sign changes
Norstrom's criterion; series starts negative; 1 sign change, therefore, one positive root

(b) $0 = -65 + 30(P/F, i, 1) + 84(P/F, i, 2) - 10(P/F, i, 3) - 12(P/F, i, 4)$

Solve for i by trial and error or spreadsheet.

$i = 28.6\%$ per year (spreadsheet)

A negative root of -56.0% is discarded.

- (c) Apply net-investment procedure steps because the investment rate $i_i = 15\%$ is not equal to i^* rate of 28.6% per year.

Hand solution:

Step 1: $F_0 = -65$	$F_0 < 0$; use i''
$F_1 = -65(1 + i'') + 30$	$F_1 < 0$; use i''
$F_2 = F_1(1 + i'') + 84$	$F_2 > 0$; use i_i (F_2 must be > 0 , because last two terms are negative)
$F_3 = F_2(1 + 0.15) - 10$	$F_3 > 0$; use i_i (F_3 must be > 0 , because last term is negative)
$F_4 = F_3(1 + 0.15) - 12$	

Step 2: Set $F_4 = 0$ and solve for i'' by trial and error.

$$F_1 = -65 - 65i'' + 30$$

$$\begin{aligned} F_2 &= (-65 - 65i'' + 30)(1 + i'') + 84 \\ &= -65 - 65i'' + 30 - 65i'' - 65i''^2 + 30i'' + 84 \\ &= -65i''^2 - 100i'' + 49 \end{aligned}$$

$$\begin{aligned} F_3 &= (-65i''^2 - 100i'' + 49)(1.15) - 10 \\ &= -74.8i''^2 - 115i'' + 56.4 - 10 \\ &= -74.8i''^2 - 115i'' + 46.4 \end{aligned}$$

$$\begin{aligned} F_4 &= (-74.8i''^2 - 115i'' + 46.4)(1.15) - 12 \\ &= -86i''^2 - 132.3i'' + 53.3 - 12 \\ &= -86i''^2 - 132.3i'' + 41.3 \end{aligned}$$

Solve by quadratic equation, trial and error, or spreadsheet.

$i'' = 26.6\%$ per year (spreadsheet)

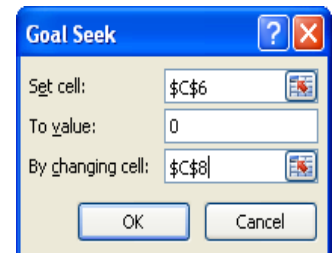
Spreadsheet solution: Using the format and functions of Figure 7-12, $i'' = 26.62\%$.

	A	B	C
1	Year	NCF, \$	Future worth value, F, \$
2	0	-65	-65
3	1	30	-35
4	2	84	49
5	3	-10	46
6	4	-12	41
7	Investment rate		15.00%
8	Result, ROIC		0.00%

Before Goal Seek

	A	B	C
1	Year	NCF, \$	Future worth value, F, \$
2	0	-65	-65
3	1	30	-52
4	2	84	18
5	3	-10	10
6	4	-12	0
7	Investment rate		15.00%
8	Result, ROIC		26.62%
9			

After Goal Seek



Goal Seek template

7.43 Descartes' rule of signs: 4 sign changes
Norstrom's criterion: series starts positive; no help

Apply the ROIC procedure with $i_i = 14\%$.

Step 1: $F_0 = 3000$

$F_0 > 0$; use i_i

$$F_1 = 3000(1 + 0.14) - 2000 \\ = 1420$$

$F_1 > 0$; use i_i

$$F_2 = 1420(1 + 0.14) + 1000 \\ = 2618.80$$

$F_2 > 0$; use i_i

$$F_3 = 2618.80(1 + 0.14) - 6000 \\ = -3014.57$$

$F_3 < 0$; use i''

$$F_4 = -3014.57(1 + i'') + 3800$$

Step 2: Set $F_4 = 0$ and solve for i''

$$0 = -3014.57(1 + i'') + 3800$$

$$i'' = 26.1\% \text{ per year}$$

7.44 Apply ROIC procedure, because investment rate $i_i = 15\%$ is not equal to $i^* = 44.1\%$ per year. In \$100 units,

$$F_0 = -5000$$

$F_0 < 0$; use i''

$$F_1 = -5000(1 + i'') + 4000 \\ = -5000 - 5000 i'' + 4000 \\ = -1000 - 5000 i''$$

$F_1 < 0$; use i''

$$\begin{aligned}
F_2 &= (-1000 - 5000 i'')(1 + i'') \\
&= -1000 - 5000 i'' - 1000 i'' - 5000 i''^2 \\
&= -1000 - 6000 i'' - 5000 i''^2
\end{aligned}$$

$F_2 < 0$; use i''

$$\begin{aligned}
F_3 &= (-1000 - 6000 i'' - 5000 i''^2)(1 + i'') \\
&= -1000 - 6000 i'' - 5000 i''^2 - 1000 i'' - 6000 i''^2 - 5000 i''^3 \\
&= -1000 - 7000 i'' - 11,000 i''^2 - 5000 i''^3
\end{aligned}$$

$F_3 < 0$; use i''

$$\begin{aligned}
F_4 &= (-1000 - 7000 i'' - 11,000 i''^2 - 5000 i''^3)(1 + i'') + 20,000 \\
&= 19,000 - 8000 i'' - 18,000 i''^2 - 16,000 i''^3 - 5000 i''^4
\end{aligned}$$

$F_4 > 0$; use i_i

$$\begin{aligned}
F_5 &= (19,000 - 8000 i'' - 18,000 i''^2 - 16,000 i''^3 - 5000 i''^4)(1.15) - 15,000 \\
&= 6850 - 9200 i'' - 20,700 i''^2 - 18,400 i''^3 - 5750 i''^4
\end{aligned}$$

Set $F_5 = 0$ and solve for i'' by trial and error or spreadsheet for the ROIC approach.

$$i'' = 35.7\% \text{ per year}$$

A spreadsheet in the format of Figure 7-12 will also indicate an EROR of 35.7% per year.

7.45 $1250 = (25,000)(b)/2$

$$b = 10\% \text{ per year, payable semiannually}$$

7.46 $I = 10,000(0.08)/4$
 $= \$200 \text{ every three months}$

7.47 $900 = (V)(0.06)/2$
 $V = \$30,000$

7.48 $I = 50,000(0.08)/4$
 $= \$1000 \text{ per quarter}$

Find P of all future payments for 15 years

$$\begin{aligned}
P &= 1000(P/A, 1.5\%, 60) + 50,000(P/F, 1.5\%, 60) \\
&= 1000(39.3803) + 50,000(0.4093) \\
&= \$59,845
\end{aligned}$$

7.49 $I = 20,000(0.08)/2$
 $= \$800 \text{ per six months}$

Find P of all future payments for 16 years

$$\begin{aligned}
 P &= 800(P/A, 6\%, 32) + 20,000(P/F, 6\%, 32) \\
 &= 800(14.0840) + 20,000(0.1550) \\
 &= \$14,367
 \end{aligned}$$

7.50 $I = 9,125,000(0.04)/4 = \$91,250$ per quarter

$$\begin{aligned}
 P &= 91,250(P/A, 1.5\%, 72) \\
 &= 91,250(43.8447) \\
 &= \$4,000,829
 \end{aligned}$$

7.51 Since the amount paid by the investor is equal to the face value of the bond, the rate of return is equal to the bond interest rate of 8% per year.

7.52 $I = 5000(0.06)/2$
 $= \$150$

$$0 = -4800 + 150(P/A, i, 40) + 5000(P/F, i, 40)$$

$i = 3.2\%$ per six months (spreadsheet)

7.53 $0 = -2000 + 10,000(P/F, i, 15)$
 $(P/F, i, 15) = 0.2000$

$i = 11.3\%$ per year (spreadsheet)

7.54 $I = 25,000,000(0.05)/2$
 $= \$625,000$ per six months

$$0 = 23,500,000 - 625,000(P/A, i, 60) - 25,000,000(P/F, i, 60)$$

$i = 2.7\%$ per six months (spreadsheet)

7.55 $I = 10,000(0.08)/4$
 $= \$200$ per quarter

(a) $0 = -6000 + 200(P/A, i, 20)(P/F, i, 8) + 7000(P/F, i, 28)$

Solve for i by trial and error or enter cash flows and use IRR function on spreadsheet.

$i = 2.55\%$ per quarter (spreadsheet)

(b) Nominal annual $i = 0.0255(4)$
 $= 10.2\%$ per year, compounded quarterly

7.56 (a) $I = 10,000,000(0.12)/4$
 $= \$300,000$ per quarter

By spending \$11 million now, the company will save \$300,000 every three months for 25 years and will save \$10,000,000 at that time. The ROR relation is:

$$0 = -11,000,000 + 300,000(P/A, i\%, 100) + 10,000,000(P/F, i\%, 100)$$

$$i = 2.71\% \text{ per quarter (spreadsheet)}$$

(b) Nominal i per year $= 2.71(4) = 10.84\%$ per year

7.57 $I = 5000(0.10)/2$
 $= \$250$ per six months

$$0 = -5000 + 250(P/A, i\%, 8) + 5500(P/F, i\%, 8)$$

Solve for i by trial and error or spreadsheet

$$i = 6.01\% \text{ per six months (spreadsheet)}$$

7.58 Answer is (b)

7.59 Answer is (d)

7.60 Answer is (b)

7.61 Answer is (a)

7.62 Answer is (b)

7.63 Answer is (b)

7.64	NCF, \$	-5000	+8000	-2000	+6000
	Cum NCF, \$	-5000	+3000	+1000	+7000

Cumulative NCF starts out negatively and changes sign only once. Answer is (a).

7.65 $-41,000 + x = 9000$
 $x = \$50,000$

Answer is (d)

7.66 Answer is (b)

7.67 Answer is (d)

7.68 Answer is (c)

7.69 Answer is (d)

7.70 Answer is (a)

7.71 Answer is (b)

7.72 $I = 10,000(0.08)/2 = \$400$

Answer is (d)

7.73 $500 = 20,000(b)/4$
 $b = 0.10$

Answer is (d)

7.74 Answer is (b)

7.75 Answer is (a)

Solution to Case Study, Chapter 7

There is not always a definitive answer to case study exercises. Here are example responses

DEVELOPING AND SELLING AN INNOVATIVE IDEA

	A	B	C	D	E	F
			NCF with sale in year 4 for \$500,000	NCF with sale in year 8 for \$100,000	NCF with new capital in year 8	Cum NCF, \$
1	Year	NCF, \$				
2	0	-200,000	-200,000	-200,000	-200,000	-200,000
3	1	55,000	55,000	55,000	55,000	-145,000
4	2	57,750	57,750	57,750	57,750	-87,250
5	3	60,638	60,638	60,638	60,638	-26,613
6	4	63,669	563,669	63,669	63,669	37,057
7	5	40,000		40,000	40,000	77,057
8	6	35,000		35,000	35,000	112,057
9	7	30,000		30,000	30,000	142,057
10	8	25,000		125,000	-175,000	-32,943
11	9	5,000			5,000	-27,943
12	10	10,000			10,000	-17,943
13	11	15,000			15,000	-2,943
14	12	20,000			20,000	17,057
15			47.9%	22.7%	4.7%	
16	ROR after 4 years	7.0%				
17	ROR after 8 years	18.8%				

1. (a) 47.9%; (b) 7.0%
2. (a) 22.7%; (b) 18.8%
3. 4.7%
4. Descartes' rule of signs: 3 sign changes
Norstrom's criterion; series starts negative; 3 sign changes

Could be up to 3 roots in the range $\pm 100\%$.
5. Continue the NCF series starting in year 13. Next 12 years of NCF at 12% has
PW = \$284,621. This is the offer based on these estimates.

Discuss why this is the correct amount to offer.

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 8
Rate of Return Analysis: Multiple Alternatives

- 8.1** The rate of return on the incremental cash flow column represents the rate of return on the *increment of investment* between the two alternatives.
- 8.2** The alternative that should be selected is the one that requires the lower initial investment.
- 8.3** He must include the first and third alternatives in an incremental analysis.
- 8.4** (a) The increment of investment between the alternatives is less than 12%.
(b) Alternative X should be selected because the ROR on the increment of investment is less than the MARR.
- 8.5** (a) The ROR on the increment is less than the MARR.
(b) Select alternative A.
- 8.6** Cannot determine which one should be selected because even though it is known that the ROR on the increment of investment is less than 22% per year, it is not known if it is equal to or greater than the company's MARR of 19%. An incremental ROR analysis must be conducted.
- 8.7** Overall ROR = $[0.30(80,000) + 0.20(50,000)]/130,000$
 $= 26.2\%$
- 8.8** $30,000(0.15) + (100,000 - 30,000)(\text{ROR}_{Z2}) = 100,000(0.30)$
$$\text{ROR}_{Z2} = .364 \quad (36.4\%)$$
- 8.9** Overall ROR = $[100,000(0.24) + 300,000(0.18) + 200,000(0.30)]/600,000$
 $= 0.23 \quad (23\%)$
- 8.10** (a) year 0: Incremental $\text{CF}_0 = -73,000 - (-12,000)$
 $= \$-61,000$
- (b) Year 2: Incremental operating cost = $-14,000 - (-27,000) = \$13,000$
- Re-purchase cost = $0 - (-12,000) = 12,000$
- Incremental $\text{CF}_2 = 13,000 + 12,000$
 $= \$25,000$

8.11	<u>Year</u>	<u>X</u>	<u>Y</u>	<u>Y - X</u>
	0	-35,000	-90,000	-55,000
	1	-31,600	-19,400	+12,200
	2	-31,600-35,000	-19,400	+47,200
	3	-31,600	-19,400	+12,200
	4	<u>-31,600</u>	<u>-19,400+8,000</u>	<u>+20,200</u>
		-196,400	-159,600	+36,800

8.12	<u>Year</u>	<u>Alternative Q</u>	<u>Alternative P</u>	<u>Q - P</u>
	0	-85,000	-50,000	-35,000
	1	43,000	13,400	29,600
	2	43,000	13,400	29,600
	3	43,000	13,400-50,000+3000	76,600
	4	43,000	13,400	29,600
	5	43,000	13,400	29,600
	6	43,000+8,000	13,400+3,000	<u>34,600</u>
			Sum = +194,600	

- 8.13** (a) Year 3 CF represents the first cost of A plus the incremental difference in their annual costs. Let P_A be the first cost of A.

$$\begin{aligned}\text{First cost of A: } 5000 + (0 - P_A) &= 12,000 \\ P_A &= \$-7000\end{aligned}$$

$$\begin{aligned}\text{(b) First cost of B: } -20,000 &= P_B - (-7000) \\ P_B &= \$-27,000\end{aligned}$$

$$\begin{aligned}\text{8.14 (a) } -40,000 &= P_{\text{Diesel}} - (-150,000) \\ P_{\text{Diesel}} &= \$-190,000\end{aligned}$$

$$\begin{aligned}\text{(b) } 11,000 &= M\&O_{\text{Diesel}} - (-41,000) \\ M\&O_{\text{Diesel}} &= \$-30,000\end{aligned}$$

$$\begin{aligned}\text{(c) } 16,000 &= S_{\text{Diesel}} - (+23,000) \\ S_{\text{Diesel}} &= \$39,000\end{aligned}$$

$$\begin{aligned}\text{8.15 (a) } -14,000 &= -65,000 - P_{\text{Anodize}} \\ P_{\text{Anodize}} &= \$-51,000\end{aligned}$$

$$\begin{aligned}\text{(b) } 5000 &= P_{\text{PC}} - (-21,000) \\ P_{\text{PC}} &= \$-16,000\end{aligned}$$

$$\begin{aligned}\text{(c) } 2000 &= 6000 - S_{\text{Anodize}} \\ S_{\text{Anodize}} &= \$4000\end{aligned}$$

8.16 (a) $0 = -4600 + 1100(P/A, \Delta i^*, 9) + 2000(P/F, \Delta i^*, 10)$

Solve for i by trial and error or spreadsheet

$\Delta i^* = 21.9\%$ per year (RATE function on spreadsheet)

(b) $\Delta i^* = 21.9\%$ per year < MARR = 25%; select Alternative P3

8.17 (a) The incremental ROR equation is:

$0 = -770,000 + 43,000(P/A, \Delta i^*, 20) + 77,000(P/F, \Delta i^*, 20)$

Solve for Δi^* by trial and error or spreadsheet

$\Delta i^* = 1.8\%$ per year (RATE function on spreadsheet)

(b) Install the tank and screen since $1.8\% < \text{MARR} = 6\%$

8.18 $0 = -45,000 + 15,000(P/A, \Delta i^*, 6) + 45,000(P/F, \Delta i^*, 3) + 6000(P/F, \Delta i^*, 6)$

Solve for i by hand using trial and error or spreadsheet.

Hand: Try $i = 40\%$: $\text{PW} = -45,000 + 15,000(2.1680) + 45,000(0.3644) + 6000(0.1328)$
 $= \$4715$ (i too low)

Try $i = 50\%$: $\text{PW} = -45,000 + 15,000(1.8244) + 45,000(0.2963) + 6000(0.0878)$
 $= \$-3774$ (i too high)

By interpolation, $\Delta i^* = 45.6\%$ per year

Spreadsheet:

	A	B	C	D
1	Year	Vinyl	Rubber	Incr CF
2	0	-50,000	-95,000	-45,000
3	1	-100,000	-85,000	15,000
4	2	-100,000	-85,000	15,000
5	3	-145,000	-85,000	60,000
6	4	-100,000	-85,000	15,000
7	5	-100,000	-85,000	15,000
8	6	-95,000	-74,000	21,000
9				
10	Δi^* using IRR function			45.2%

By IRR function, $\Delta i^* = 45.2\%$ per year

Conclusion: Since $\Delta i^* > \text{MARR} = 21\%$, select the fiber-impregnated rubber alternative.

8.19 $0 = -700,000 + 65,000(P/A, \Delta i^*, 20)$
 $(P/A, \Delta i^*, 20) = 10.7692$

Solve for Δi^* by trial and error or spreadsheet

$\Delta i^* = 6.8\%$ per year (RATE function on spreadsheet)

$\Delta i^* > \text{MARR of } 6\%$ per year; select design 4R, the more expensive one.

8.20 Write rate of return equation for increment between B and A.

$0 = -65,000 + 25,000(P/A, \Delta i^*, 3)$
 $(P/A, \Delta i^*, 3) = 2.6000$

Solve for Δi^* by interpolation in interest tables or spreadsheet

$\Delta i^* = 7.5\% < \text{MARR of } 20\%$; select additive A (spreadsheet)

8.21 (a) Construct tabulation to get incremental cash flow.

Year	Cash flows, \$1000		Incremental
	Type Fe	Type Al	cash flow, \$1000 (Al - Fe)
0	-150	-280	-130
1	-92	-74	18
2	$-92 + 30 - 150$	-74	138
3	-92	-74	18
4	$-92 + 30$	$-74 + 70$	58

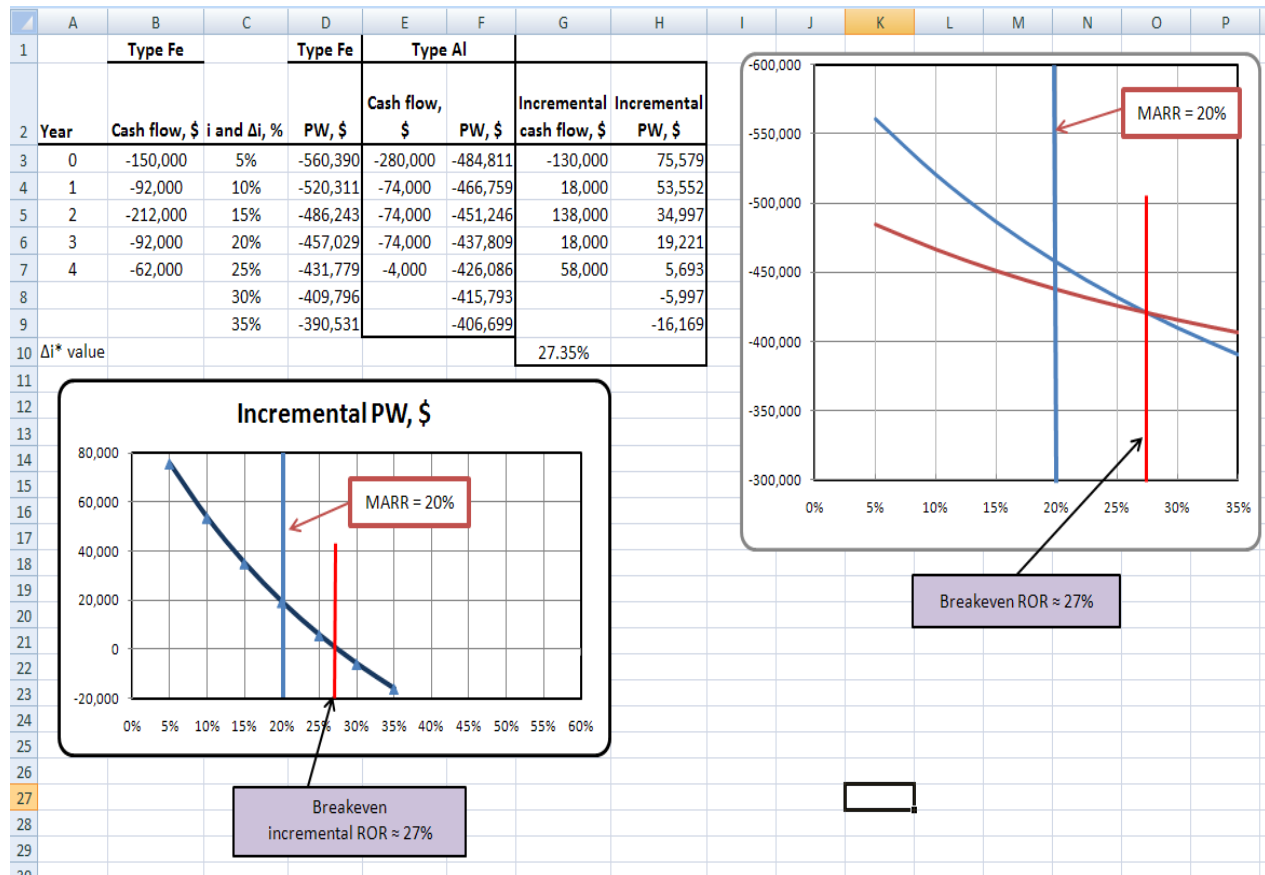
$0 = -130 + 18(P/A, \Delta i^*, 4) + 120(P/F, \Delta i^*, 2) + 40(P/F, \Delta i^*, 4)$

Spreadsheet: Enter incremental cash flows and use IRR function to display

$\Delta i^* = 27.3\%$

Since $27.3\% > \text{MARR} = 20\%$; select type Al (spreadsheet)

(b) and (c) Plots are developed using i and Δi values. Decision is the same to select A1.



$$8.22 \quad 0 = -900,000 + AOC(P/A, 40\%, 3)$$

$$0 = -900,000 + AOC(1.5889)$$

$$AOC = \$566,430$$

$$\text{Required reduction} = 566,430 - 400,000$$

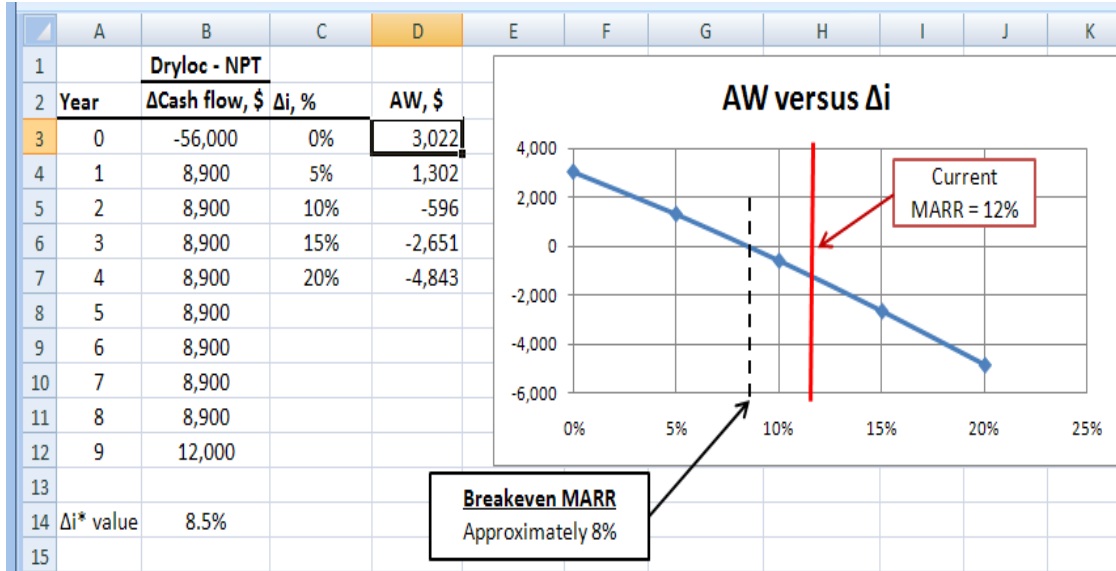
$$= \$166,430 \text{ per year}$$

$$8.23 \text{ (a)} \quad 0 = -56,000(A/P, \Delta i^*, 9) + 8900 + (12,000 - 8900)(A/F, \Delta i^*, 9)$$

Solve for Δi^* by trial and error or spreadsheet

$$\Delta i^* = 8.5\% < \text{MARR}; \text{ select Dryloc} \quad (\text{spreadsheet})$$

(b) The maximum MARR is $\Delta i^* = 8.5\%$. Any $\text{MARR} > 8.5\%$ indicates selection of Dryloc.



8.24 Variable speed has the larger initial investment.

$$0 = -25,000(A/P, \Delta i^*, 6) + 4000 + 40,000(A/F, \Delta i^*, 6)$$

Solve for Δi^* by trial and error or spreadsheet

$$\Delta i^* = 21.8\% \quad (\text{RATE function})$$

$\Delta i^* > \text{MARR} = 18\%$; select variable speed, the higher investment alternative

8.25 Find ROR for incremental cash flow over LCM of 4 years.

$$0 = -31,000(A/P, \Delta i^*, 4) - 5000 + 40,000(P/F, \Delta i^*, 2)(A/P, \Delta i^*, 4) + 18,000(A/F, \Delta i^*, 4)$$

Solve for Δi^* by trial and error or spreadsheet

$$\Delta i^* = 8.0\% \quad (\text{spreadsheet})$$

$\Delta i^* < \text{MARR} = 18\%$; select DBB valves

8.26 (a) EMT has a larger initial investment than HP

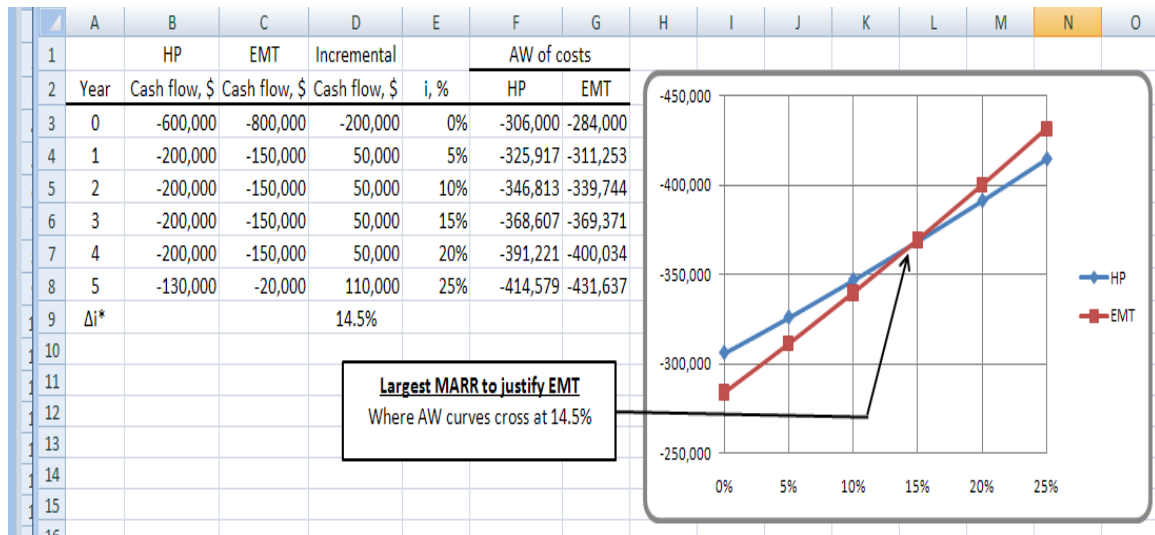
$$0 = -200,000(A/P, \Delta i^*, 5) + 50,000 + 60,000(A/F, \Delta i^*, 5)$$

Solve for Δi^* by trial and error or spreadsheet

$$\Delta i^* = 14.5\% \quad (\text{RATE function})$$

$\Delta i^* < \text{MARR}$; select hydraulic machine (HP)

(b) Graph of AW of costs versus i values



8.27 (a) He used overall i^* values rather than incremental i^* values.

(b) Determine Δi^* and compare to each MARR.

	A	B	C	D	E	F	G	H
1	Alternative A			Alternative B			Incremental	
2	Year	Revenue, \$	Costs, \$	NCF, \$	Revenue, \$	Costs, \$	NCF, \$	NCF, \$
3	0		-40,000	-40,000		-85,000	-85,000	-45,000
4	1	22,000	-5,500	16,500	45,000	-15,000	30,000	13,500
5	2	22,000	-5,500	16,500	45,000	-15,000	30,000	13,500
6	3	22,000	-5,500	16,500	45,000	-15,000	30,000	13,500
7	4	22,000	-5,500	16,500	45,000	-15,000	30,000	13,500
8	5	22,000	-5,500	16,500	45,000	-15,000	30,000	13,500
9	6	22,000	-5,500	16,500	65,000	-15,000	50,000	33,500
10	i^* and Δi^*			34.2%			29.2%	25.1%

MARR = 30%: $\Delta i^* = 25.1\% < \text{MARR}$; select A

MARR = 20%: $\Delta i^* = 25.1\% > \text{MAR}$ R; select B

(c) Ranking inconsistency occurs for revenue alternative comparison when the MARR is set lower than Δi^* . At MARR = 20%, this occurs and A is incorrectly selected if overall ROR values are used as the basis of selection.

8.28 Do-nothing alternative.

8.29 Revenue alternatives; calculate overall ROR first and compare to MARR =10%.

$$i_{44}^* = 4.2\% \quad (\text{eliminate})$$

$$i_{55}^* = 6.0\% \quad (\text{eliminate})$$

$$i_{88}^* = 10.7\% \quad (\text{retain})$$

Rank remaining alternative by increasing initial investment: DN, 88

$$\begin{aligned} \text{DN vs 88:} \quad 0 &= -61,000 + 7500(P/A, \Delta i^*, 20) \\ (P/A, \Delta i^*, 20) &= 8.1333 \end{aligned}$$

Solve for Δi^* by trial and error or spreadsheet

$$\Delta i^* = 10.7\% \text{ per year} \quad (\text{RATE function})$$

$$\Delta i^* > \text{MARR} = 10\%; \text{ select 88 Mbps}$$

8.30 Revenue alternatives; calculate overall ROR first and compare to MARR =15%. Then rank remaining alternatives according to increasing initial investment (including DN) and compare incrementally. ROR values determined by RATE function.

$$i_{i\text{Gen-1}}^* = -12.6\% \quad (\text{eliminate})$$

$$i_{i\text{Gen-2}}^* = -2.7\% \quad (\text{eliminate})$$

$$i_{i\text{Gen-3}}^* = 4.3\% \quad (\text{eliminate})$$

$$i_{i\text{Gen-4}}^* = 17.8\% \quad (\text{retain})$$

$$i\text{Gen-4 vs DN:} \quad 0 = -750,000 + 310,000(P/A, \Delta i^*, 3) + 120,000(P/F, \Delta i^*, 3)$$

$$\Delta i^* = 17.8\%; \quad \text{select } i\text{Gen-4}$$

8.31 Cost alternatives. Rank alternatives according to increasing initial investment and compare incrementally: 2, 1, 3, 5, 4. Δi^* values determined by RATE function on a spreadsheet.

$$1 \text{ vs } 2: \quad 0 = -2000 + 3300(P/A, \Delta i^*, 4)$$

$$\Delta i^* = 161\%; \quad \text{eliminate 2}$$

$$3 \text{ vs } 1: \quad 0 = -3500 - 1000(P/A, \Delta i^*, 4)$$

$$\Delta i^* < 0\%; \quad \text{eliminate 3}$$

$$5 \text{ vs } 1: \quad 0 = -10,000 + 500(P/A, \Delta i^*, 4)$$

$$\Delta i^* < 0\%; \quad \text{eliminate 5}$$

$$4 \text{ vs } 1: \quad 0 = -18,000 + 3800(P/A, \Delta i^*, 4)$$

$$\Delta i^* = -6.4\%; \quad \text{eliminate 4}$$

Select machine 1

8.32 Rank alternatives according to increasing initial investment (including DN) and compare incrementally: DN, D, A, C, E, B

- (a) DN vs D: $\Delta i^* = 11\%$ < MARR eliminate D
DN vs A: $\Delta i^* = 10\%$ < MARR eliminate A
DN vs C: $\Delta i^* = 7\%$ < MARR eliminate C
DN vs E: $\Delta i^* = 12\%$ > MARR eliminate DN
E vs B: $\Delta i^* = 15\%$ > MARR eliminate E

Therefore, select B

- (b) DN vs D: $\Delta i^* = 11\%$ < MARR eliminate D
DN vs A: $\Delta i^* = 10\%$ < MARR eliminate A
DN vs C: $\Delta i^* = 7\%$ < MARR eliminate C
DN vs E: $\Delta i^* = 12\%$ < MARR eliminate E
DN vs B: $\Delta i^* = 13\%$ < MARR eliminate B

Therefore, select DN

8.33 (a) None have an overall ROR \geq to MARR; select Do-nothing

(b) Retain B, D and E since their overall ROR > MARR

B vs. D = 38.5%; eliminate B

D vs. E = 6.8%; eliminate E

Therefore, select D

(c) Select B, D, and E

8.34 Ranking: DN, D, A, C, E, B. Use $\Delta i^* = \Delta A / \Delta P$ as the incremental measure; MARR is 14.9%.

D vs. DN: $\Delta i^* = 16.7\%$; eliminate DN, keep D

A vs. D: $\Delta i^* = 500/4000 = 12.4\%$; eliminate A, keep D

C vs. D: $\Delta i^* = 900/6000 = 15\%$; eliminate D, keep C

E vs. C: $\Delta i^* = 800/7000 = 11.4\%$; eliminate E, keep C

B vs. C: $\Delta i^* = 2100/14,000 = 15\%$; eliminate C, keep B

Select B

8.35 (a) Rank alternatives: E,D,C,B,A; eliminate E,D and A because overall ROR < MARR

C vs. B: $\Delta i^* = 14\%$; eliminate B; select alternative C

(b) Rank alternatives: E,D,C,B,A; eliminate E because overall ROR < MARR

C vs. D: $\Delta i^* = 35\%$, eliminate D

B vs. C: $\Delta i^* = 14\%$, eliminate C

A vs. B: $\Delta i^* = 12\%$, eliminate B (Note that Δi^* exactly equals MARR)

Select alternative A

8.36 Only machines 2 and 3 have overall ROR greater than 22%. Increment between 2 and 3 (3-to-2 comparison) is not justified; select machine 2.

8.37 (a) Select projects A and B

(b) Must do incremental analysis between A and B using $\Delta i^* = \Delta A / \Delta P$

A vs. B: $\Delta i^* = (700/10,000) = 7\%$ per year

$\Delta i^* < \text{MARR} = 7.5\%$; eliminate A, select project B

8.38 Answer is (b)

8.39 Answer is (d)

8.40 Answer is (b)

8.41 Answer is (d)

8.42 Answer is (c)

8.43	<u>Year</u>	<u>A</u>	<u>B</u>	<u>B - A</u>
	0	-10,000	-14,000	-4000
	1	+2500	+4000	+1500
	2	+2500	+4000	+1500
	3	+2500	+4000	+1500
	4	+2500	+4000	+1500
	5	<u>+2500</u>	<u>+4000</u>	<u>+1500</u>
			Sum =	+3500

Answer is (b)

8.44 Answer is (a)

8.45 Answer is (b)

8.46 Answer is (c)

8.47 Answer is (c)

8.48 Answer is (c)

Solution to Case Studies, Chapter 8

Sometimes, there is not a definitive answer to a case study exercise. Here are example responses.

ROR ANALYSIS WITH ESTIMATED LIVES THAT VARY

1. PW at 12% is shown in row 29. Select server #2 (n = 8) with the largest PW value.
2. #1 (n = 3) is eliminated. It has $i^* < \text{MARR} = 12\%$. Perform an incremental analysis of #1 (n = 4) and #2 (n = 5). Column H shows $\Delta i^* = 19.5\%$. Now perform an incremental comparison of #2 for n = 5 and n = 8. This is not necessary since no extra investment is necessary to expand cash flow by three years. The Δi^* is infinity. It is obvious: select #2 (n = 8).
3. PW at 2000% > \$0.05. Δi^* is infinity, as shown in cell K45, where an error for IRR(K4:K44) is indicated.

	A	B	C	D	E	F	G	H	I	J	K
1	MARR =	12%						#2(n=5)-to-#1(n=4)			#2(8)-to-#2(5)
2		#1 (n = 3)	#1 (n = 4)	#2 (n = 5)	#2 (n = 8)	#1(n=4)	#2 (n=5)	Incremental	#2 (n=5)	#2 (n = 8)	Incremental
3	Year	Cash flow	Cash flow	Cash flow	Cash flow	20 yr. CF	20 yr. CF	cash flow	40 yr. CF	40 yr. CF	cash flow
4	0	-100,000	-100,000	-200,000	-200,000	-100,000	-200,000	-100,000	-200,000	-200,000	0
5	1	35,000	35,000	50,000	50,000	35,000	50,000	15,000	50,000	50,000	0
6	2	35,000	35,000	55,000	55,000	35,000	55,000	20,000	55,000	55,000	0
7	3	35,000	35,000	60,000	60,000	35,000	60,000	25,000	60,000	60,000	0
8	4		35,000	65,000	65,000	-65,000	65,000	130,000	65,000	65,000	0
9	5			70,000	70,000	35,000	-130,000	-165,000	-130,000	70,000	200,000
10	6			70,000	70,000	35,000	70,000	35,000	70,000	70,000	0
11	7			70,000	70,000	35,000	70,000	35,000	70,000	70,000	0
12	8			70,000	70,000	-65,000	70,000	135,000	70,000	-130,000	-200,000
13	9					35,000	70,000	35,000	70,000	70,000	0
14	10					35,000	-130,000	-165,000	-130,000	70,000	200,000
15	11					35,000	70,000	35,000	70,000	70,000	0
16	12					-65,000	70,000	135,000	70,000	70,000	0
17	13					35,000	70,000	35,000	70,000	70,000	0
18	14					35,000	70,000	35,000	70,000	70,000	0
19	15					35,000	-130,000	-165,000	-130,000	70,000	200,000
20	16					-65,000	70,000	135,000	70,000	-130,000	-200,000
21	17					35,000	70,000	35,000	70,000	70,000	0
22	18					35,000	70,000	35,000	70,000	70,000	0
23	19					35,000	70,000	35,000	70,000	70,000	0
24	20					35,000	70,000	35,000	-130,000	70,000	200,000
25	Overall i*	2.5%	15.0%	14.3%	25.0%	Δi^*		19.5%	70,000	70,000	0
26	Retain or		Retain	Retain	Retain		Retain		70,000	70,000	0
27	Eliminate?	Eliminate				Eliminate			70,000	70,000	0
28									70,000	-130,000	-200,000
29	PW @12%	-15,936	6,307	12,224	107,624				-130,000	70,000	200,000
30	26								70,000	70,000	0
31	27								70,000	70,000	0
32	28								70,000	70,000	0
33	29								70,000	70,000	0
34	30								70,000	70,000	0
35	31								70,000	70,000	0
36	32								70,000	70,000	0
37	33								70,000	70,000	0
38	34								70,000	70,000	0
39	35								70,000	70,000	0
40	36								70,000	70,000	0
41	37									Δi^*	#DIV/0!
42	38									PW at 3000%	0.01
43	39										
44	40										
45											
46											

Solution to Case Studies, Chapter 8

Sometimes, there is not a definitive answer to a case study exercise. Here are example responses.

HOW A NEW ENGINEERING GRADUATE CAN HELP HIS FATHER

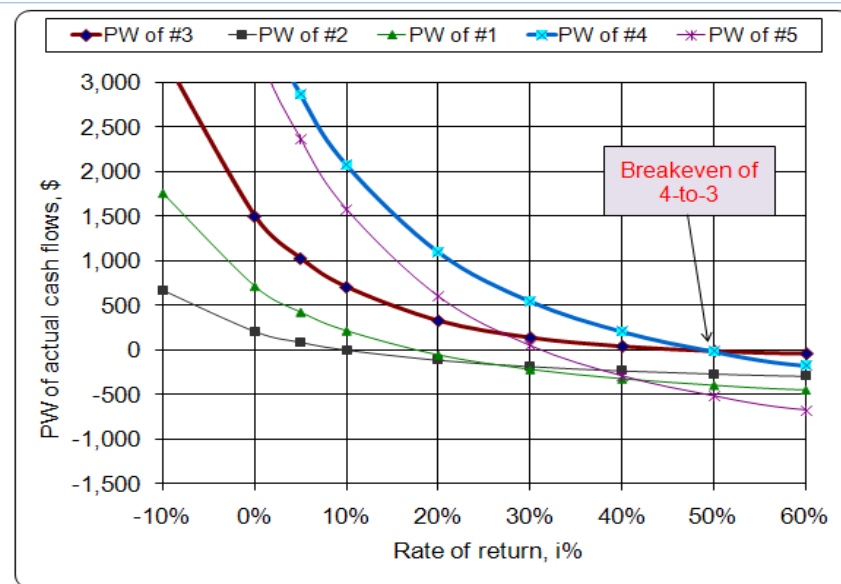
1. Cash flows for each option are summarized at top of the spreadsheet. Rows 9-19 show annual estimates for options in increasing order of initial investment: 3, 2, 1, 4, 5.

	A	B	C	D	E	F	G	H	I
1	MARR =	25%	ROR, PW, AW analysis		(Cash flows, \$1000 units)				
2	Alternative		#3	#2	#1	#4		#5	
3	Initial cost		0	-400	-750	-1,000		-1,500	
4	Est. annual expenses		\$-1250, yrs 1-5	\$-1400(1-5); -2000(6-10)	\$-800+6%/yr	-3,000		-500	
5	Est. annual revenues		\$1150 (1-5)	\$1400+5%/yr	\$1000+4%/yr	3,500		1,000	
6	Sale of business revenue		\$500 (5-8)						
7	Life	Year	10	10	10	10		10	
8	Incr. ROR comparison		Actual CF	Actual CF	Actual CF	Actual CF	4-to-3	Actual CF	5-to-4
9	Incremental investment	0	0	-400	-750	-1,000	-1,000	-1,500	-500
10	Incremental cash flow	1	-100	0	200	500	600	500	0
11		2	-100	70	192	500	600	500	0
12		3	-100	144	183	500	600	500	0
13		4	-100	221	172	500	600	500	0
14		5	400	302	160	500	100	500	0
15		6	500	-213	146	500	0	500	0
16		7	500	-124	131	500	0	500	0
17		8	500	-30	113	500	0	500	0
18		9	0	68	93	500	500	500	0
19		10	0	172	72	500	500	500	0
20	Overall i*		46.4%	10.1%	17.4%	49.1%		31.1%	
21	Retain or eliminate?		Retain	Eliminate	Eliminate	Retain		Retain	
22	Incremental i*						49.9%		#NUM!
23	Increment justified?						Yes		No
24	Alternative selected						4		4
25	PW at MARR		215	-152	-146	785		285	-500
26	AW at MARR		60			220		80	
27	Alternative acceptable?		Yes			Yes		Yes	
28	Alternative selected					4			

2. Multiple i* values: Only for option #2; there are 3 sign changes in cash flow and cumulative cash flow series. No values other than 10.1% are found in the 0 to 100% range.
3. Do incremental ROR analysis after removing #1 and #2. See row 22. 4-to-3 comparison yields 49.9%, 5-to-4 has no return because all incremental cash flows are 0 or negative. PW at 25% is \$785 for #4, which is the largest PW. Aw is also the largest for #4.

Conclusion: Select option #4 – trade-out with friend.

4. PW vs. i charts for all 5 options are on the spreadsheet.



Options compared	Approximate breakeven
1 and 2	26%
3 and 5	27
2 and 5	38
1 and 5	42
3 and 4	50

5. Force the breakeven rate of return between options #4 and #3 to be equal to MARR = 25%. Use trial and error or Goal Seek with a target cell of G22 to equal 25% and changing cell of C6 (template at right). Make the values in years 5 through 8 of option #3 equal to the value in cell C6, so they reflect the changes. The answer obtained should be about \$1090, which is actually \$1,090,000 for each of 4 years.

Required minimum selling price is $4(1090,000) = \$4.36$ million compared to the current appraised value of \$2 million.

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 9
Benefit/Cost Analysis and Public Sector Economics

- 9.1** Disbenefits are negative consequences that occur *to the public* and, therefore, are included in the numerator of the B/C ratio. Costs are consequences *to the government* and are included in the denominator.
- 9.2** eBay – *private*; farmer’s market – *private*; state police department – *public*; car racing facility – *private*; social security – *public*; EMS - *public*, ATM – *private*; travel agency- *private*; amusement park – *private*; gambling casino - *private*; swap meet - *private*; football stadium - *public*.
- 9.3** Large initial investment – *public*; park user fees – *public*; short life projects – *private*; profit – *private*; disbenefits – *public*; tax-free bonds – *public*; subsidized loans – *public*; low interest rate – *public*; income tax – *private*; water quality standards – *public*.
- 9.4**
- | | |
|----------------|----------------|
| (a) Disbenefit | (e) Benefit |
| (b) Benefit | (f) Disbenefit |
| (c) Benefit | (g) Disbenefit |
| (d) Cost | (h) Benefit |
- 9.5** In a DBOMF contract arrangement, the contractor is responsible for managing the cash flow to support project implementation; not the funding (capital funds) aspects. In DBOM contracts, this management responsibility is not placed on the contractor.
- 9.6** Answers will vary considerably depending upon a person’s own beliefs and perspective. A sample answer to part (a) follows.
1. Plant manager: sales revenues, customers
 2. Sheriff’s deputy: legal matters, service to public
 3. County commissioner: politics, revenue and budget
 4. Security company president: revenue and budget, contract obligations
- 9.7** The salvage value is included in the denominator and is subtracted from the first cost.
- 9.8** $B = 900,000(1.5) - 900,000 = \$450,000$
- $$\begin{aligned}C &= 300,000 + 25,000(P/A, 6\%, 20) \\&= 300,000 + 25,000(11.4699) \\&= \$586,748\end{aligned}$$
- $$B/C = 450,000/586,748 = 0.77$$

$$\begin{aligned} 9.9 \quad B/C &= [50(4,000,000)]/[200(90,000,000)] \\ &= 0.01 \end{aligned}$$

$$\begin{aligned} 9.10 \quad B &= 90,000 \\ D &= 10,000 \end{aligned}$$

$$\begin{aligned} C &= 750,000(A/P, 8\%, 20) + 50,000 \\ &= 750,000(0.10185) + 50,000 \\ &= \$126,388 \end{aligned}$$

$$S = 30,000$$

$$\begin{aligned} B/C &= (B-D)/(C-S) \\ &= (90,000 - 10,000)/(126,388 - 30,000) \\ &= 0.83 \end{aligned}$$

$$\begin{aligned} 9.11 \quad B &= \$820,000 \\ D &= \$400,000 \end{aligned}$$

$$\begin{aligned} C &= 2,000,000(A/P, 8\%, 20) + 100,000 \\ &= 2,000,000(0.10185) + 100,000 \\ &= \$303,700 \end{aligned}$$

$$\begin{aligned} B/C &= (820,000 - 400,000)/303,700 \\ &= 1.38 \end{aligned}$$

9.12 First convert all cash flows to AW values

$$\begin{aligned} B &= 30,800,000(A/F, 7\%, 20) \\ &= 30,800,000(0.02439) \\ &= \$751,212 \end{aligned}$$

$$D = \$105,000$$

$$\begin{aligned} C &= 1,200,000(A/P, 7\%, 20) + 400,000 \\ &= 1,200,000(0.09439) + 400,000 \\ &= \$513,268 \end{aligned}$$

$$\begin{aligned} B/C &= (751,212 - 105,000)/513,268 \\ &= 1.26 \end{aligned}$$

$$\begin{aligned} 9.13 \quad B/C &= [10,000/0.10]/[50,000 + 50,000(P/F, 10\%, 2)] \\ &= [100,000]/[50,000 + 50,000(0.8264)] \\ &= 1.1 \end{aligned}$$

9.14 (a) PI does not include disbenefits. NCF are savings plus benefits.

$$\begin{aligned}\text{PW of NCF} &= 20,000 + 30,000(\text{P/F}, 10\%, 5) + 2000(\text{P/A}, 10\%, 20) \\ &= 20,000 + 30,000(0.6209) + 2000(8.5136) \\ &= \$55,654\end{aligned}$$

$$C = \$50,000$$

$$\begin{aligned}\text{PI} &= 55,654/50,000 \\ &= 1.11\end{aligned}$$

(b) Modified B/C includes disbenefit estimates and savings are added to benefits.

$$\begin{aligned}B &= 20,000 + 30,000(\text{P/F}, 10\%, 5) \\ &= 20,000 + 30,000(0.6209) \\ &= \$38,627\end{aligned}$$

$$\begin{aligned}D &= 3000(\text{P/A}, 10\%, 10) \\ &= 3000(6.1446) \\ &= \$18,433\end{aligned}$$

$$C = \$50,000$$

$$\begin{aligned}S &= 2000(\text{P/A}, 10\%, 20) \\ &= 2000(8.5136) \\ &= \$17,027\end{aligned}$$

$$\begin{aligned}\text{Modified B/C} &= (38,627 - 18,433 + 17,027)/50,000 \\ &= 37,221/50,000 \\ &= 0.74\end{aligned}$$

9.15 Must find n so that one of missing values can be calculated. Use first cost.

$$\begin{aligned}100,000 &= 259,370(\text{P/F}, 10\%, n) \\ (\text{P/F}, 10\%, n) &= 0.3855\end{aligned}$$

From 10% interest table and P/F column, $n = 10$

$$\begin{aligned}\text{PW benefits} &= 40,000(\text{P/A}, 10\%, 10) \\ &= 40,000(6.1446) \\ &= \$245,784\end{aligned}$$

$$\begin{aligned}(B - D)/C &= (245,784 - 30,723)/(100,000 + 61,446) \\ &= 1.33\end{aligned}$$

9.16 Let P = first cost

$$1.4 = 560,000/AW_P$$
$$AW_P = 400,000$$

$$400,000 = P(A/P, 6\%, 20)$$
$$400,000 = P(0.08718)$$
$$P = \$4,588,208$$

9.17 $B = 175,000,000(P/A, 8\%, 5)$
 $= 175,000,000(3.9927)$
 $= \$698,722,500$

$$D = 30,000,000$$

$$C = 110,000,000 + 50,000,000(P/A, 8\%, 2)$$
$$= 110,000,000 + 50,000,000(1.7833)$$
$$= \$199,165,000$$

$$B/C = (B-D)/C = (698,722,500 - 30,000,000)/199,165,000$$
$$= 3.36$$

9.18 P is the initial investment. To obtain modified $B/C = 1.0$, solve for AW of P ; then find P .

$$\text{Modified } B/C = (AW \text{ of } B - AW \text{ of } C)/(AW \text{ of } P) = 1.0$$

$$AW \text{ of } P = (AW \text{ of } B) - (AW \text{ of } C)$$
$$P(A/P, 6\%, 10) = 800,000 - 600,000$$
$$P(0.13587) = 200,000$$
$$P = \$1,471,995$$

9.19 (a) Use an AW basis

$$B = \$340,000$$
$$D = \$40,000$$
$$C = 2,300,000(0.06) + 120,000$$
$$= \$258,000$$

$$B/C = (340,000 - 40,000)/258,000$$
$$= 1.16$$

(b) Use an AW basis

$$\text{Annual upkeep cost} = 120,000$$

$$\text{Initial investment} = P(i) = 2,300,000(0.06) = \$138,000 \text{ per year}$$

$$\begin{aligned}\text{Modified B/C} &= (340,000 - 40,000 - 120,000)/138,000 \\ &= 1.30\end{aligned}$$

9.20 Use annual worth, since most of the cash flows are in annual dollars.

(a) Conventional B/C ratio

$$\begin{aligned}B &= 300,000(0.06) + 100,000 \\ &= 18,000 + 100,000 \\ &= \$118,000\end{aligned}$$

$$D = \$40,000$$

$$\begin{aligned}C &= 1,500,000(0.06) + 200,000(P/F, 6\%, 3)(0.06) \\ &= 90,000 + 200,000(0.8396)(0.06) \\ &= \$100,075\end{aligned}$$

$$S = 70,000$$

$$\begin{aligned}B/C &= (118,000 - 40,000)/(100,075 - 70,000) \\ &= 2.59\end{aligned}$$

$$\begin{aligned}\text{(b) Modified B/C ratio} &= (B - D + S)/C \\ &= (118,000 - 40,000 + 70,000)/100,075 \\ &= 1.48\end{aligned}$$

9.21 Convert annual benefits, designated as A in years 6 through infinity, to an A value in years 1 through 5. Let B indicate \$ billion.

$$\begin{aligned}B &= (A/0.08)(A/F, 8\%, 5) \\ D &= [40,000(100,000) + 1B]/5 = \$1B \text{ per year for 5 years} \\ C &= 11B/5 = \$2.2B \text{ per year for 5 years}\end{aligned}$$

$$\begin{aligned}1.0 &= (B - D)/C \\ 1.0 &= [(A/0.08)(A/F, 8\%, 5) - 1B]/2.2B \\ 1.0 &= [(A/0.08)(0.17046) - 1B]/2.2B\end{aligned}$$

$$\begin{aligned}2.2B &= 0.17046A/0.08 - 1B \\ A &= \$1.5018 \text{ billion per year}\end{aligned}$$

9.22 $B = 30(4,000,000) = \$120 \text{ million per year}$

$$\begin{aligned}C &= 20,000(100,000)(A/P, 10\%, 15) \\ &= 2 \text{ billion}(0.13147) \\ &= \$262.940 \text{ million per year}\end{aligned}$$

$$\begin{aligned} B/C &= 120 \text{ million} / 262.940 \text{ million} \\ &= 0.46 \end{aligned}$$

9.23 $B = 8,200,000 + 13,000(460) = \$14,180,000$ per year

$$\begin{aligned} C &= 220,000,000(A/P, 6\%, 30) \\ &= 220,000,000(0.07265) \\ &= \$15,983,000 \end{aligned}$$

$$\begin{aligned} B/C &= 14,180,000 / 15,983,000 \\ &= 0.89 \end{aligned}$$

9.24 $B = 20,000 + 30,000(P/F, 6\%, 5)$
 $= 20,000 + 30,000(0.7473)$
 $= \$42,419$

$$\begin{aligned} D &= 7000(P/F, 6\%, 3) \\ &= 7000(0.8396) \\ &= \$5877 \end{aligned}$$

$$C = \$100,000$$

$$\begin{aligned} S &= 25,000(P/A, 6\%, 4) \\ &= 25,000(3.4651) \\ &= \$86,628 \end{aligned}$$

$$\begin{aligned} (B - D)/(C - S) &= (42,419 - 5877)/(100,000 - 86,628) \\ &= 2.73 \end{aligned}$$

9.25 The modified B/C ratio includes any estimated disbenefits; the PI does not

9.26 In \$ million units,

$$\begin{aligned} \text{PW of net savings} &= 1.2(P/A, 8\%, 5) + 2.5(P/A, 8\%, 5)(P/F, 8\%, 5) \\ &= 1.2(3.9927) + 2.5(3.9927)(0.6806) \\ &= \$11.58 \end{aligned}$$

$$\begin{aligned} \text{PW of investments} &= 4.2 + 3.5(P/F, 8\%, 5) \\ &= 4.2 + 3.5(0.6806) \\ &= \$6.58 \end{aligned}$$

$$PI = 11.58/6.58 = 1.76$$

9.27 In \$1000 units,

$$\begin{aligned}\text{PW of NCF} &= 5(P/A, 10\%, 6) + 2(P/G, 10\%, 6) \\ &= 5(4.3553) + 2(9.6842) \\ &= \$41.14\end{aligned}$$

$$\begin{aligned}\text{PW of investments} &= 25 + 10(P/F, 10\%, 2) + 5(P/F, 10\%, 4) \\ &= 25 + 10(0.8264) + 5(0.6830) \\ &= \$36.68\end{aligned}$$

$$\begin{aligned}\text{PI} &= 41.14/36.68 \\ &= 1.12\end{aligned}$$

The project was economically justified since $\text{PI} > 1.0$

9.28 Select the alternative that has the higher cost.

9.29 The B/C ratio on the increment of investment between X and Y is > 1.8 .

9.30 MS vs. DN: $B = (150,000,000)(3.00/1000)$
 $= \$450,000$

$$\begin{aligned}C &= 4,200,000(A/P, 8\%, 20) + 280,000 \\ &= 4,200,000(0.10185) + 280,000 \\ &= \$707,770\end{aligned}$$

$$\begin{aligned}B/C &= 450,000/707,770 \\ &= 0.64\end{aligned}$$

Eliminate mountain site

VS vs. DN: $B = (890,000,000)(3.00/1000)$
 $= \$2,670,000$

$$\begin{aligned}C &= 11,000,000(A/P, 8\%, 20) + 400,000 \\ &= 11,000,000(0.10185) + 400,000 \\ &= \$1,520,350\end{aligned}$$

$$\begin{aligned}B/C &= 2,670,000/1,520,350 \\ &= 1.76\end{aligned}$$

Select VS, the valley site, since $B/C > 1.0$

9.31 East vs. DN: $(B-D)_{\text{East}} = 990,000 - 120,000 = \$870,000$ per year
 $C_{\text{East}} = 11,000,000(0.06) + 100,000 = \$760,000$ per year

$$\begin{aligned}(B-D)/C &= 870,000/760,000 \\ &= 1.14\end{aligned}$$

Eliminate DN

West vs. East: $\Delta(B-D) = (2,400,000 - 100,000) - (990,000 - 120,000) = \$1,430,000$
 $\Delta C = [27,000,000(0.06) + 90,000] - 760,000 = \$950,000$

$$\begin{aligned}\Delta B/C &= 1,430,000/950,000 \\ &= 1.51\end{aligned}$$

Select West location

9.32 Proposal 1 vs. DN: $B = 530,000$
 $D = 300,000$
 $C = 900,000(A/P, 8\%, 10) + 120,000$
 $= 900,000(0.14903) + 120,000$
 $= 254,127$

$$\begin{aligned}B/C &= (530,000 - 300,000)/254,127 \\ &= 0.91\end{aligned}$$

Eliminate Proposal 1

Proposal 2 vs. DN: $B = 650,000$
 $D = 195,000$
 $C = 1,700,000(A/P, 8\%, 20) + 60,000$
 $= 1,700,000(0.10185) + 60,000$
 $= 233,145$

$$\begin{aligned}B/C &= (650,000 - 195,000)/233,145 \\ &= 1.95\end{aligned}$$

Eliminate DN, since $B/C > 1.0$

Select Proposal 2

9.33 Both are cost alternatives; DN is not considered and solar is the challenger. Difference in annual cost is a benefit to solar.

$$\Delta B = 700,000 - 5000 = 695,000$$

$$\begin{aligned}\Delta C &= (2,500,000 - 300,000)(A/P, 8\%, 5) \\ &= (2,200,000)(0.25046) \\ &= 551,012\end{aligned}$$

$$\begin{aligned}\Delta B/C &= 695,000/551,012 \\ &= 1.26 \quad \text{Eliminate conventional}\end{aligned}$$

Therefore, select Solar

9.34 EC vs DN: B = \$110,000 per year
D = \$26,000 per year
 $C = 38,000(A/P, 7\%, 10) + 49,000$
 $= 38,000(0.14238) + 49,000$
 $= \$54,410$

$$\begin{aligned}(B-D)/C &= (110,000 - 26,000)/54,410 \\ &= 1.54 \quad \text{Eliminate DN}\end{aligned}$$

$$\begin{aligned}\text{NS vs EC: } \Delta B &= 160,000 - 110,000 \\ &= \$50,000\end{aligned}$$

$$\begin{aligned}\Delta D &= 0 - 26,000 \\ &= \$-26,000\end{aligned}$$

Cost EC = \$54,410 (from above)

$$\begin{aligned}\text{Cost NS} &= 87,000(A/P, 7\%, 10) + 64,000 \\ &= 87,000(0.14238) + 64,000 \\ &= \$76,387\end{aligned}$$

$$\begin{aligned}\Delta C &= 76,387 - 54,410 \\ &= \$21,977\end{aligned}$$

$$\begin{aligned}\Delta(B-D)/C &= [50,000 - (-26,000)]/21,977 \\ &= 3.46 \quad \text{Eliminate EC}\end{aligned}$$

Select NS, the new sensors

9.35 Both are cost alternatives; no comparison to DN.

$$\begin{aligned}\text{Cost for method \#1} &= 14,100 + 6000 + 4300 + 2600 \\ &= \$27,000\end{aligned}$$

$$\begin{aligned}\text{Cost for method \#2} &= \$5200 + 1400 + 2600 + 1200 \\ &= \$10,400\end{aligned}$$

$$\begin{aligned}\text{\#2 vs. \#1: } \Delta C &= 27,000 - 10,400 \\ &= \$16,600\end{aligned}$$

$$\begin{aligned}\Delta B &= 600(P/A, 7\%, 20) \\ &= 600(10.5940) \\ &= \$6356\end{aligned}$$

$$\begin{aligned}\Delta B/C &= 6356/16,600 \\ &= 0.38\end{aligned}\quad \text{Eliminate \#1}$$

Select method #2

9.36 Alternatives involve only costs; DN is not an option. Calculate AW of total costs.

$$\begin{aligned}C_{SS} &= 26,000,000(A/P, 8\%, 20) + 400,000 \\ &= 26,000,000(0.10185) + 400,000 \\ &= \$3,048,000\end{aligned}$$

$$\begin{aligned}C_{OC} &= 53,000,000(A/P, 8\%, 20) + 30,000 \\ &= 53,000,000(0.10185) + 30,000 \\ &= \$5,428,000\end{aligned}$$

Cleanup costs are a benefit to OC

$$\Delta B = \$60,000$$

$$\begin{aligned}\Delta B/C &= (60,000 - 0) / (5,428,000 - 3,048,000) \\ &= 0.03\end{aligned}\quad \text{Eliminate open channels}$$

Build sanitary sewers

9.37 (a) All cash flows are costs; DN is not an option. Incremental analysis is necessary. Benefits are defined by road usage cost difference. Short route has larger initial cost.

$$\begin{aligned}\Delta B &= \text{difference in road user costs between long and short route} \\ &= 400,000(25)(0.30) - 400,000(10)(0.30) \\ &= \$1,800,000\end{aligned}$$

$$\begin{aligned}\Delta C &= (45M - 25M)(0.08) + (35,000 - 150,000) \\ &= \$1,485,000\end{aligned}$$

$$\begin{aligned}\Delta B/C &= 1,800,000/1,485,000 \\ &= 1.21\end{aligned}$$

Select short transmountain route, since $\Delta B/C > 1.0$

(b) Modified $\Delta B/C = (\Delta B - \Delta \text{annual costs})/\Delta \text{initial investment}$

$$\Delta B = [400,000(25)(0.30) - 400,000(10)(0.30)] - (35,000 - 150,000) \\ = 1,915,000$$

$$\Delta \text{initial investment} = (45,000,000 - 25,000,000)(0.08) \\ = \$1,600,000$$

$$\text{Modified } \Delta B/C = 1,915,000/1,600,000 \\ = 1.20$$

Select short transmountain route

9.38 (a) Revenue alternatives; compare location E to DN

Location E

$$\text{AW of C} = 3,000,000(0.12) + 50,000 \\ = \$410,000$$

$$\text{Revenue} = B = \$500,000 \text{ per year} \\ \text{Disbenefits} = D = \$30,000 \text{ per year}$$

Location W

$$\text{AW of C} = 7,000,000 (0.12) + 65,000 - 25,000 \\ = \$880,000$$

$$\text{Revenue} = B = \$700,000 \text{ per year} \\ \text{Disbenefits} = D = \$40,000 \text{ per year}$$

B/C ratio for location E:

$$(B - D)/C = (500,000 - 30,000)/410,000 \\ = 1.15$$

Location E is economically justified. W is now incrementally compared to E.

$$\text{W vs. E: } \Delta C = 880,000 - 410,000 \\ = \$470,000$$

$$\Delta B = 700,000 - 500,000 \\ = \$200,000$$

$$\Delta D = 40,000 - 30,000 \\ = \$10,000$$

$$\Delta(B-D)/C = (200,000 - 10,000)/470,000 \\ = 0.40$$

Since $\Delta(B - D)/C < 1$, W is not justified; select location E.

(b) Location E

$$B = 500,000 - 30,000 - 50,000 = \$420,000$$

$$C = 3,000,000 (0.12) = \$360,000$$

$$\text{Modified } B/C = 420,000/360,000 = 1.17$$

Location E is justified. Incrementally compare W to E.

$$\text{W vs. E: } \Delta B = \$200,000$$

$$\Delta D = \$10,000$$

$$\Delta \text{initial cost} = (7 \text{ million} - 3 \text{ million})(0.12) \\ = \$480,000$$

$$\Delta \text{operating costs} = (65,000 - 25,000) - 50,000 \\ = \$-10,000$$

Note that operating cost is now an incremental advantage for W.

$$\text{Modified } \Delta B/C = \frac{200,000 - 10,000 - (-10,000)}{480,000} = 0.42$$

W is not justified; select location E.

9.39 Set up the spreadsheet to find AW of costs, perform the initial B/C analyses using cell reference format. Changes from part to part needed should be the estimates and possibly a switching of which options are incrementally justified. All 3 analyses are done on a rolling spreadsheet shown below.

(a) Bob: Compare 1 vs. DN, then 2 vs. 1. Select option 1

(b) Judy: Compare 1 vs. DN, then 2 vs. 1. Select option 2

(c) Chen: Compare 2 vs. DN, then 1 vs. 2. Select option 2 without doing the $\Delta B/C$ analysis, since benefits minus disbenefits for 1 are less, but this option has a larger AW of costs than option 2.

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Arial 10

	A	B	C	D	E	F	G	H	I	J	K
1	Part (a) Analysis by Engineer Bob										
2	Discount rate	10%									
3											
4		Option 1	Option 2		1 vs DN		2 vs 1				
5											
6	Initial cost, \$	50,000	90,000								
7	Cost, \$/yr	3,000	4,000								
8	AW of costs, \$/yr	16,190	27,742	Delta C	16,190		11,552				
9	Benefits, \$/yr	20,000	29,000	Delta B	20,000		9,000				
10	Disbenefits, \$/yr	500	1,500	Delta D	500		1,000				
11	Life, yrs	5	5								
12				Delta B/C	1.20	Do 1	0.69	Do 1			
13	Part (b) Analysis by Engineer Judy										
14	Discount rate	10%									
15											
16		Option 1	Option 2		1 vs DN		2 vs 1				
17											
18	Initial cost, \$	75,000	90,000								
19	Cost, \$/yr	3,800	3,000								
20	AW of costs, \$/yr	23,585	26,742	Delta C	23,585		3,157				
21	Benefits, \$/yr	30,000	35,000	Delta B	30,000		5,000				
22	Disbenefits, \$/yr	1,000	0	Delta D	1000		-1,000				
23	Life, yrs	5	5								
24				Delta B/C	1.23	Do 1	1.90	Do 2			

Delta B/C = (\$G9-\$G10)/\$G8
=IF(\$G12>1,"Do 2","Do 1")

Sheet1 / Sheet2 / Sheet3

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Arial 10

	A	B	C	D	E	F	G	H	I	J	K
26	Part (c) Analysis by Engineer Chen. Must switch order of comparison to 1 vs 2										
27	Discount rate	10%									
28											
29		Option 1	Option 2		2 vs DN		1 vs 2				
30											
31	Initial cost, \$	60,000	70,000								
32	Cost, \$/yr	6,000	3,000								
33	AW of costs, \$/yr	21,828	21,466	Delta C	21,466		362				
34	Benefits, \$/yr	30,000	35,000	Delta B	35,000		-5,000				
35	Disbenefits, \$/yr	5,000	1,000	Delta D	1,000		4,000				
36	Life, yrs	5	5								
37				Delta B/C	1.58	Do 2	-24.86	Do 2			
38	AW of costs = -(PMT(\$B27,\$B36, -PV(\$B27,\$B36,\$B32)+\$B31))										
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											
50											

=IF(\$E38>1,"Do 2","Do 1")

Not a meaningful B/C value since option 1 has larger AW of costs, but provides a lower (B-D) value. Incremental analysis not needed, simply select option 2

Sheet1 / Sheet2 / Sheet3

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- 9.40 (a) $B/C_A = 70/80 = 0.88$
 $B/C_B = 55/50 = 1.10$
 $B/C_C = 76/72 = 1.06$
 $B/C_D = 52/43 = 1.21$
 $B/C_E = 85/89 = 0.95$
 $B/C_F = 84/81 = 1.04$

Select all alternatives that have $B/C \geq 1.0$. Select B, C, D, and F

(b) Rank acceptable alternatives (i.e., $B/C \geq 1.0$) by increasing cost (D, B, C, F) and do incremental analysis

$$\begin{aligned} \text{B vs. D: } \Delta B/C &= (55 - 52)/(50 - 43) \\ &= 0.43 \quad \text{Eliminate B} \end{aligned}$$

$$\begin{aligned} \text{C vs. D: } \Delta B/C &= (76 - 52)/(72 - 43) \\ &= 0.83 \quad \text{Eliminate C} \end{aligned}$$

$$\begin{aligned} \text{F vs. D: } \Delta B/C &= (84 - 52)/(81 - 43) \\ &= 0.84 \quad \text{Eliminate F} \end{aligned}$$

Select alternative D

- 9.41** A vs. B < 1.0; eliminate B
 A vs. C > 1.0; eliminate A
 C vs. D > 1.0; eliminate C
 D vs. E < 1.0; eliminate E

Select D

9.42 (a) $B/C_{\text{Good}} = (15,000 - 6,000)/(10,000 - 1,500)$
 = 1.06

$$\begin{aligned} B/C_{\text{Better}} &= (11,000 - 1,000)/(8,000 - 2,000) \\ &= 1.67 \end{aligned}$$

$$\begin{aligned} B/C_{\text{Best}} &= (25,000 - 20,000)/(20,000 - 16,000) \\ &= 1.25 \end{aligned}$$

$$\begin{aligned} B/C_{\text{Best of all}} &= (42,000 - 32,000)/(14,000 - 3,000) \\ &= 0.91 \end{aligned}$$

Select Good, Better, and Best

(b) Rank acceptable alternatives in terms of increasing FW of net cost

$$\text{Best: } 20,000 - 16,000 = \$4,000$$

$$\text{Better: } 8,000 - 2,000 = \$6,000$$

$$\text{Good: } 10,000 - 1,500 = \$8,500$$

$$\begin{aligned} \text{Better vs. Best: } \Delta B/C &= [(11,000 - 1,000) - (25,000 - 20,000)]/(6,000 - 4,000) \\ &= 2.5 \quad \text{Eliminate Best} \end{aligned}$$

$$\text{Good vs. Better: } \Delta B/C = [(15,000 - 6,000) - (11,000 - 1,000)] / (8,500 - 6,000) < 0 \quad \text{Eliminate Good}$$

Select Better

9.43 Ranking: DN, A, C, E, F, B, D

$$\text{A vs. DN: } B/C = 1.23 > 1.0 \quad \text{Eliminate DN}$$

Eliminate C, D, and E because $B/C < 1.0$

$$\text{F vs. A: } \Delta B/C = 1.02 > 1.0 \quad \text{Eliminate A}$$

$$\text{B vs. F: } \Delta B/C = 1.20 > 1.0 \quad \text{Eliminate F}$$

Select B

9.44 Ranking is A, B, C, D. Eliminate A because $B/C < 1.0$

$$\text{B vs. DN: } B/C = 1.18 \quad \text{Eliminate DN}$$

$$\text{C vs. B: } \Delta B/C = 0.58 \quad \text{Eliminate C}$$

$$\text{D vs. B: } \Delta B/C = 1.13 \quad \text{Eliminate B}$$

Select D

$$\begin{aligned} \text{9.45 (a) PW of } B_J: 1.05 &= (B - 1)/20 \\ B &= 22 \end{aligned}$$

$$\begin{aligned} \text{PW of } D_K: 1.13 &= (28 - D)/23 \\ D &= 2 \end{aligned}$$

$$\text{PW of } B/C_L: (B - D)/C = (35 - 3)/28 = 1.14$$

$$\begin{aligned} \text{PW of } C_M: 1.34 &= (51 - 4)/C \\ C &= 35 \end{aligned}$$

Incremental B/C calculations

$$\begin{aligned} \text{K vs. J: } \Delta B/C &= [(28 - 2) - (22 - 1)] / (23 - 20) \\ &= 1.67 \end{aligned}$$

$$\begin{aligned} \text{L vs. J: } \Delta B/C &= [(35 - 3) - (22 - 1)] / (28 - 20) \\ &= 1.38 \end{aligned}$$

$$\text{M vs. J: } \Delta B/C = [(51 - 4) - (22 - 1)] / (35 - 20) \\ = 1.73$$

$$\text{L vs. K: } \Delta B/C = [(35 - 3) - (28 - 2)] / (28 - 23) \\ = 1.20$$

$$\text{M vs. K: } \Delta B/C = [(51 - 4) - (28 - 2)] / (35 - 23) \\ = 1.75$$

$$\text{M vs. L: } \Delta B/C = [(51 - 4) - (35 - 3)] / (35 - 28) \\ = 2.14$$

(b) Revenue alternatives. Perform the incremental comparisons

J vs. DN: $B/C = 1.05$	Eliminate DN
K vs. J: $\Delta B/C = 1.67$	Eliminate J
L vs. K: $\Delta B/C = 1.20$	Eliminate K
M vs. L: $\Delta B/C = 2.14$	Eliminate L

Select M

9.46 Strategies are independent; calculate CER values, rank in increasing order and select those to not exceed \$50/employee.

$$\begin{aligned} \text{CER}_A &= 5.20/50 = 0.10 \\ \text{CER}_B &= 23.40/182 = 0.13 \\ \text{CER}_C &= 3.75/40 = 0.09 \\ \text{CER}_D &= 10.80/75 = 0.14 \\ \text{CER}_E &= 8.65/53 = 0.16 \\ \text{CER}_F &= 15.10/96 = 0.16 \end{aligned}$$

	A	B	C	D	E
1					Cumulative
2	Strategy	C, \$	E	CER	cost, \$
3	C	3.75	40	0.09	3.75
4	A	5.20	50	0.10	8.95
5	B	23.40	182	0.13	32.35
6	D	10.80	75	0.14	43.15
7	F	15.10	96	0.16	58.25
8	E	8.65	53	0.16	66.90
9					

Select strategies C, A, B and D to not exceed \$50 per employee. Parts of F may be a possibility to use the remaining of the \$50.

- 9.47** (a) Methods are independent. Calculate CER values, rank in increasing order, select lowest CER, determine total cost.

$$\begin{aligned} \text{CER}_{\text{Acupuncture}} &= 700/9 = 78 \\ \text{CER}_{\text{Subliminal}} &= 150/1 = 150 \\ \text{CER}_{\text{Aversion}} &= 1700/10 = 170 \\ \text{CER}_{\text{Out-patient}} &= 2500/39 = 64 \\ \text{CER}_{\text{In-patient}} &= 1800/41 = 44 \\ \text{CER}_{\text{NRT}} &= 1300/20 = 65 \end{aligned}$$

Lowest CER is 44 for in-patient. Annual program cost is

$$1800(550) = \$990,000$$

- (b) Rank by CER (column 4) and select techniques to treat 1300 people. Request is for \$2,295,000 (column 8).

	A	B	C	D	E	F	G	H
1		Cost	% quit,		Annual	Cumulative	Cost per	Cumulative
2	Method	C, \$	E	CER	capacity	capacity	year, \$	cost, \$
3	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
4	In-patient clinic	1800	41	44	550	550	990,000	990,000
5	Out-patient clinic	2500	39	64	400	950	1,000,000	1,990,000
6	NRT	1300	20	65	100	1050	130,000	2,120,000
7	Acupuncture	700	9	78	250	1300	175,000	2,295,000
8	Subliminal message	150	1	150	500	1800	75,000	2,370,000
9	Aversion therapy	1700	10	170	200	2000	340,000	2,710,000

- 9.48** (a) $\text{CER}_W = 355/20 = 17.8$
 $\text{CER}_X = 208/17 = 12.2$
 $\text{CER}_Y = 660/41 = 16.1$
 $\text{CER}_Z = 102/7 = 14.6$

- (b) Rank alternatives according to E, salvaged items/year (lowest to highest): Z, X, W, Y. Perform incremental comparison.

$$\text{X to Z: } \Delta C/E = (208 - 102)/(17 - 7) = 10.6 < 14.6$$

Z is dominated; eliminate Z

$$\text{W to X: } \Delta C/E = (355 - 208)/(20 - 17) = 49 > 12.2$$

Keep W and X; W is new defender

$$Y \text{ to } W: \Delta C/E = (660 - 355)/(41 - 20) = 14.5 < 17.8$$

W is dominated; eliminate W

Only X and Y remain.

$$Y \text{ to } X: \Delta C/E = (660 - 208)/(41 - 17) = 18.8 > 12.2$$

No dominance; both X and Y are acceptable; final decision made on other criteria.

9.49 Minutes are the cost, C, and points gained are the effectiveness measure, E. Order on basis of E and calculate CER values, then perform $\Delta C/E$ analysis.

$$E = 5; \text{ Friend: } C/E = 10/5 = 2$$

$$E = 10; \text{ Slides: } C/E = 20/10 = 2$$

$$E = 15; \text{ TA: } C/E = 15/15 = 1$$

$$E = 15; \text{ Professor: } C/E = 20/15 = 1.33$$

$$\text{Friend vs. DN: } C/E = 2 \quad \text{Basis for comparison}$$

$$\text{Slides vs. friend: } \Delta C/E = (20-10)/(10-5) = 2$$

No dominance; keep both; slides is new defender

$$\text{TA vs. slides: } \Delta C/E = (15-20)/(15-10) = -1$$

Slides are dominated, eliminate slides; TA is new defender

Professor vs. TA: TA has less cost for same effectiveness; professor is dominated.

$$\Delta C/E = (20-15)/(15-15) = \text{undefined}$$

Only TA and friend remain.

$$\text{TA vs. friend: } \Delta C/E = (15-10)/(15-5) = 0.5 < C/E = 2 \text{ for friend}$$

Friend is dominated; go to TA for assistance

9.50 A discussion question open for different responses.

9.51 Public policy deals with *strategy* and *policy* review and development. Public planning includes the design of *projects* and *efforts* necessary to implement the strategy, once finalized.

9.52 Some example projects to be described might be:

- Change of ingress and egress ramps for all major thoroughfares
- Signage changes coordinated to make the switch at the correct time
- Training programs to help drivers understand how to drive this different way
- Notification programs and progress reports to the public

9.53 Answer is (d)

9.54 Answer is (b)

9.55 Answer is (b)

9.56 Answer is (c)

9.57 Answer is (b)

9.58 Answer is (d)

9.59 Answer is (d)

9.60 Answer is (d)

$$\begin{aligned}\mathbf{9.61} \quad B/C &= (50,000 - 27,000)/[250,000(0.10) + 10,000] \\ &= 0.66\end{aligned}$$

Answer is (b)

$$\mathbf{9.62} \quad B/C = (60,000 - 29,000 - 15,000)/20,000 = 0.8$$

Answer is (c)

9.63 Answer is (d)

$$\begin{aligned}\mathbf{9.64} \quad 1.5 &= 50,000/(0.10P + 10,000) \\ P &= \$233,333\end{aligned}$$

Answer is (d)

9.65 Answer is (b)

$$\mathbf{9.66} \quad \Delta C/E = (33,000 - 25,000)/(6 - 4) = 4000$$

Answer is (c)

9.67 Answer is (b)

9.68 Answer is (c)

9.69 Answer is (a)

Solution to Case Study, Chapter 9

Sometimes, there is not a definitive answer to a case study exercise. Here are example responses.

COMPARING B/C ANALYSIS AND CEA OF TRAFFIC ACCIDENT REDUCTION

Computations similar to those for benefits (B), costs (C) and effectiveness measure (E) of accidents prevented in the case study for each alternative results in the following estimates.

	Benefits	Effectiveness	Cost, \$ per year		
Alternative	B, \$/year	Measure, C	Poles	Power	Total
W	1,482,000	247	1,088,479	459,024	1,547,503
X	889,200	148	544,240	229,512	773,752
Y	1,111,500	185	777,485	401,646	1,179,131
Z	744,000	124	388,743	200,823	589,566

1. B/C analysis order based on total costs: Z, X, Y, W. Challenger is placed first below.

Z vs. DN: $B/C = 744,000/589,566 = 1.26$ eliminate DN

X vs. Z: $\Delta B/C = (889,200-744,000)/(773,752-589,566) = 0.79$ eliminate X

Y vs. Z: $\Delta B/C = (1,111,500-744,000)/(1,179,131-589,566) = 0.62$ eliminate Y

W vs. Z: $\Delta B/C = (1,482,000-744,000)/(1,547,503-589,566) = 0.77$ eliminate W

Select alternative Z -- wider pole spacing, cheaper poles and lower lumens

2. C/E analysis order based on effectiveness measure, E: Z, X, Y, W. Challenger listed first.

Calculate C/E for each alter native.

$$C/E_W = 1,547,503/247 = 6265$$

$$C/E_X = 773,752/148 = 5228$$

$$C/E_Y = 1,179,131/185 = 6374$$

$$C/E_Z = 589,566/124 = 4755$$

Z vs. DN: $C/E = 4755$ basis for comparison

X vs. Z: $\Delta C/E = (773,752-589,566)/(148-124) = 7674 > 4755$ no dominance, keep both

Y vs. X: $\Delta C/E = (1,179,131 - 773,752)/(185 - 148) = 10,956 > 5228$ no dominance, keep both

W vs. Y: $\Delta C/E = (1,547,503 - 1,179,131)/(247 - 185) = 5941 < 6374$ dominance, eliminate Y

Remaining alternatives in order are: Z, X, W

X vs. Z: $\Delta C/E = 7674$ (calculated above) no dominance, keep both

W vs. X: $\Delta C/E = (1,547,503 - 773,752)/(247 - 148) = 7816 > 5228$ no dominance, keep both

Three alternatives -- Z, X and W -- are indicated as a possible choice. The decision for one must be made on a basis other than C/E, probably the amount of budget available.

3. Ratio of night/day accidents, lighted = $839/2069 = 0.406$

If the same ratio is applied to unlighted sections, number of accidents prevented is calculated as follows:

$$0.406 = \frac{\text{no. of accidents}}{379}$$

Number of accidents = 154

Number prevented = $199 - 154 = 45$

4. For Z to be justified, the incremental comparison of W vs. Z would have to be ≥ 1.0 . The benefits would have to increase. Find B_w in the incremental comparison.

W vs. Z: $\Delta B/C = (B_w - 744,000)/(1,547,503 - 589,566)$

$$1.0 = (B_w - 744,000)/(957,937) \\ B_w = 1,701,937$$

The difference in the number of accidents would have to increase from 247 to:

$$1,701,937 = (\text{difference})(6000) \\ \text{Difference} = 284$$

From the day estimate in the case study of 1086 accidents without lights, now

Number of accidents would have to be = $1086 - 284 = 802$

New night/day ratio = $802/2069 = 0.387$

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 10
Project Financing and Non-economic Attributes

10.1 Risk – The higher the risk, the higher the MARR

Investment Opportunity – MARR may be lowered for “pet projects” or for company to expand into target areas.

Government Intervention – May result in higher or lower MARRs, depending on how the intervention affects the company’s competitiveness

Tax structure – Higher taxes induce companies to raise the MARR and vice versa

Limited capital – Limited availability of capital results in increased MARRs as companies attempt to deploy the capital most effectively

Market rates – higher interest rates increase the cost of capital, requiring a higher MARR

- 10.2** (a) Equity
(b) Equity
(c) Debt
(d) Debt
(e) Equity

10.3 Before-tax MARR = $0.12 / (1 - 0.40)$
= 0.20 (20%)

10.4 (a) Effective tax rate = $0.07 + (0.93)(0.22) = 0.275$

From Equation [10.1]

Before-tax MARR = $0.15 / (1 - 0.275)$
= 0.207 (20.7%)

(b) Bid amount = $7.2 \text{ million} / (1 - 0.207)$
= \$9.08 million

10.5 $0.29 = \text{after-tax return} / (1 - 0.32)$

After-tax return = 19.7%

10.6 ROR measure: Select projects A and E to total \$13 million. Opportunity cost is ROR = 20.4% for project C

PW measure: Select projects A and C to total \$16 million. Opportunity cost is ROR = 26.0% for project E

10.7 (a) $MARR = WACC + \text{required return} = 8\% + 4\%$
 $= 12\%$

The 3% risk factor is considered after the project is evaluated; not added to the MARR

(b) Evaluate the project and determine the ROR. If it is 15% and Tom rejects the proposal, his MARR is effectively 15% per year.

10.8 The debt portion of \$18 million represents 45% of the total.

$$\begin{aligned}\text{Total amount of financing} &= 18,000,000/0.45 \\ &= \$40,000,000\end{aligned}$$

10.9 D-E mix: Debt = 12 + 20 = \$32 million
 Equity = 5 + 10 = \$15 million

$$\begin{aligned}\% \text{ debt} &= 32/(32 + 15) = 68\% \\ \% \text{ equity} &= 15/47 = 32\%\end{aligned}$$

D-E mix is 68-32

10.10 (a) Business: all debt; D-E = 100 to 0

Engineering: all debt; D-E = 100 to 0

(b) Business: $FW = 30,000(F/P, 4\%, 1)$
 $= 30,000(1.04)$
 $= \$31,200$

Check is for \$31,200 to student loan office

$$\begin{aligned}\text{Engineering: } FW &= 25,000(1) + 25,000(F/P, 7\%, 1) \\ &= 25,000(1 + 1.07) \\ &= \$51,750\end{aligned}$$

Two checks: \$25,000 to parents and \$26,750 to credit union

(c) Business: 4%

$$\text{Engineering: } 0.5(0\%) + 0.5(7\%) = 3.5\%$$

10.11 First Engineering: Fraction debt = $87/175 \approx 50\%$

$$\text{Fraction equity} = (175-87)/175 \approx 50\%$$

Basically, a 50-50 D-E mix

Midwest Development: Fraction debt = $(175-62)/175 = 64.6\%$

Fraction equity = $62/175 = 35.4\%$

Approximately, a 65-35 D-E mix

10.12 Company's equity = $50(0.40) = \$20$ million

Return on equity = $5/20 = 0.25$ (25%)

10.13 Total financing = $3 + 4 + 6 = \$13$ million

$$\begin{aligned} \text{WACC} &= (3/13)(0.15) + (4/13)(0.09) + (6/13)(0.07) \\ &= 9.46\% \end{aligned}$$

10.14 (a) $\text{WACC}_1 = 0.5(9\%) + 0.5(6\%) = 7.5\%$

$$\text{WACC}_2 = 0.2(9\%) + 0.8(8\%) = 8.2\%$$

Plan 1 has a lower WACC

(b) Let x = cost of debt capital

$$\begin{aligned} \text{WACC}_1 &= 8.2\% = 0.5(9\%) + 0.5x \\ x &= 7.4\% \end{aligned}$$

$$\begin{aligned} \text{WACC}_2 &= 8.2\% = 0.2(9\%) + 0.8x \\ x &= 8.0\% \end{aligned}$$

Plan 1 cost of debt goes up from 6% to 7.4%; Plan 2 maintains the same cost.

10.15 $\text{WACC} = \text{cost of debt capital} + \text{cost of equity capital}$
 $= (0.4)[0.667(8\%) + 0.333(10\%)] + (0.6)[(0.4)(5\%) + (0.6)(9\%)]$
 $= 0.4[8.667\%] + 0.6 [7.4\%]$
 $= 7.907\%$

10.16 Solve for the cost of debt capital, x

$$\begin{aligned} \text{WACC} &= 11.1\% = 0.75(7\%) + (1 - 0.75)(x) \\ x &= (11.1 - 5.25)/0.25 \\ &= 23.4\% \end{aligned}$$

10.17 (a) Determine the after-tax cost of debt capital, Equation [10.4], and WACC

$$\text{After-tax cost of debt capital} = 10(1 - 0.36) = 6.4\%$$

$$\text{After-tax WACC} = 0.35(6.4\%) + 0.65(14.5\%) = 11.665\%$$

Interest charged to revenue for the project:

$$14.0 \text{ million}(0.11665) = \$1,633,100$$

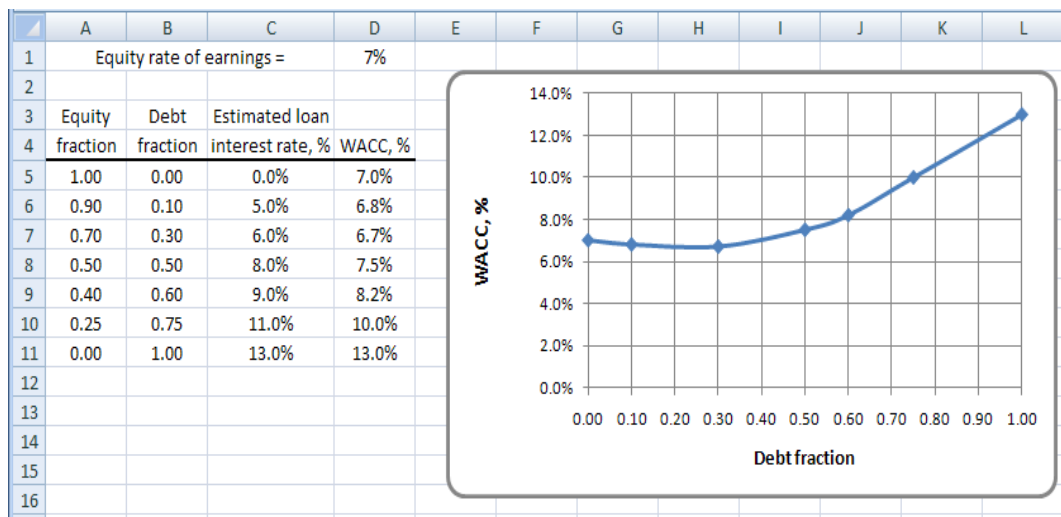
(b) After-tax WACC = $0.25(14.5\%) + 0.75(6.4\%)$
 $= 8.425\%$

Interest charged to revenue for the project:

$$14.0 \text{ million}(0.08425) = \$1,179,500$$

As more and more capital is borrowed, the company risks higher loan rates and owns less and less of itself. Debt capital (loans) becomes more expensive and harder to acquire.

10.18 The lowest WACC value of 6.7% occurs at the debt fraction of 0.3 or \$30,000 in loans. This translates into funding \$70,000 from their own funds.

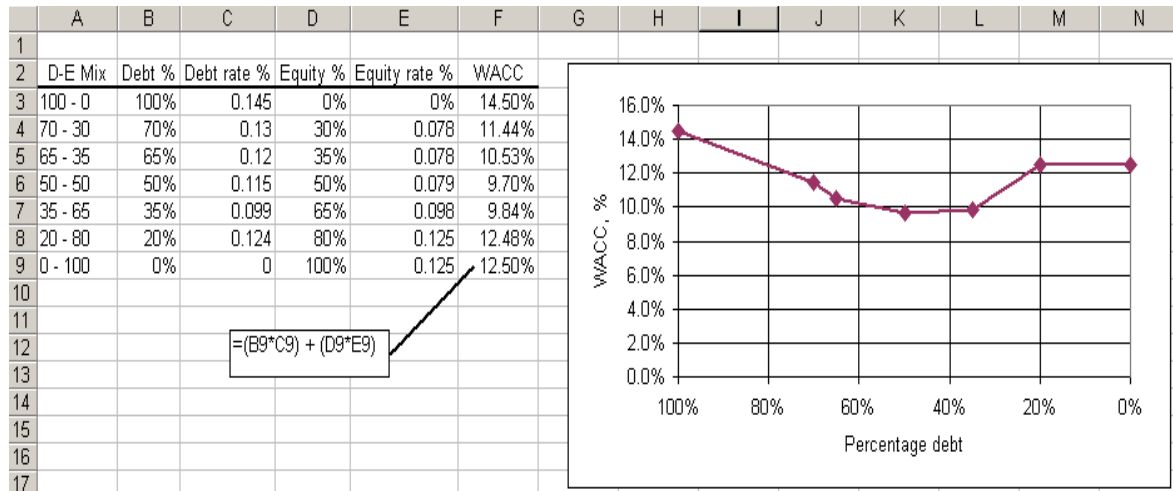


10.19 (a) Compute and plot WACC for each D-E mix. See plot in problem 10.20 below.

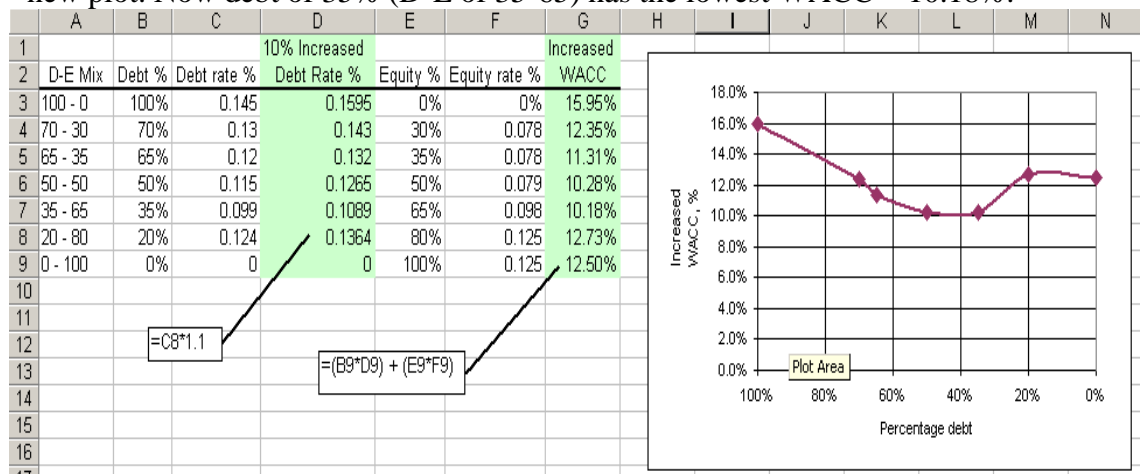
D-E mix	WACC
100-0	14.50%
70-30	11.44
65-35	10.53
50-50	9.70
35-65	9.84
20-80	12.48
0 - 100	12.50

(b) D-E mix of 50%-50% has the lowest WACC value.

10.20 (a) The spreadsheet shows a 50% - 50% mix to have the lowest WACC at 9.70%.



(b) Multiply the debt rate (column C) by 1.1 to add the 10% (column D) and observe the new plot. Now debt of 35% (D-E of 35-65) has the lowest WACC = 10.18%.



10.21 (a) $0 = 2,800,000 - 196,000(P/A, i^*, 10) - 2,800,000(P/F, i^*, 10)$

$i^* = 7.0\%$ (RATE function on spreadsheet)

Before-tax cost of debt capital is 7.0% per year

(b) Tax savings = $196,000(0.33) = \$64,680$

$NCF = 196,000 - 64,680 = \$131,320$

$0 = 2,800,000 - (131,320)(P/A, i^*, 10) - 2,800,000$

$i^* = 4.7\%$ (RATE function)

After-tax cost of debt capital is 4.7% per year

10.22 (a) $0 = 19,000,000 - 1,200,000(P/A, i^*, 15) - 20,000,000(P/F, i^*, 15)$

$i^* = 6.53\%$ (spreadsheet)

Before-tax cost of debt capital is 6.53% per year

(b) Tax savings = $1,200,000(0.29) = \$348,000$

$NCF = 1,200,000 - 348,000 = \$852,000$

$0 = 19,000,000 - (852,000)(P/A, i^*, 15) - 20,000,000(P/F, i^*, 15)$

$i^* = 4.73\%$ (spreadsheet)

After-tax cost of debt capital is 4.73% per year

10.23 Bond interest = $\frac{0.06(3,100,000)}{2} = \$93,000$ every 6 months

Dividend semi-annual net cash flow = $\$93,000(1 - 0.32) = \$63,240$

The rate of return equation per 6-months over 15(2) semi-annual periods is:

$0 = 3,100,000 - 63,240(P/A, i^*, 30) - 3,100,000(P/F, i^*, 30)$

$i^* = 2.04\%$ per 6 months (spreadsheet)

(a) Nominal $i^*/\text{year} = 2(2.04) = 4.08\%$ per year

(b) Effective $i^*/\text{year} = (1.0204)^2 - 1 = 0.0412$ (4.12% per year)

10.24 (a) Bank loan

Annual loan payment = $800,000(A/P, 8\%, 8)$
 $= 800,000(0.17401)$
 $= \$139,208$

Principal payment = $800,000/8 = \$100,000$

Annual interest = $139,208 - 100,000 = \$39,208$

Tax saving = $39,208(0.40) = \$15,683$

Effective interest payment = $39,208 - 15,683 = \$23,525$

Effective annual payment = $23,525 + 100,000 = \$123,525$

The AW-based i^* relation is:

$0 = 800,000(A/P, i^*, 8) - 123,525$

$$(A/P, i^*, 8) = \frac{123,525}{800,000} = 0.15441$$

$$i^* = 4.95\% \quad (\text{RATE function})$$

Bond issue

$$\text{Annual bond dividend} = 800,000(0.06) = \$48,000$$

$$\text{Tax saving} = 48,000(0.40) = \$19,200$$

$$\text{Effective bond dividend} = 48,000 - 19,200 = \$28,800$$

The AW-based i^* relation is:

$$0 = 800,000(A/P, i^*, 10) - 28,800 - 800,000(A/F, i^*, 10)$$

$$i^* = 3.60\% \quad (\text{RATE or IRR function})$$

Bond financing is cheaper.

- (b) Before taxes: Bonds cost 6% per year, which is less than the 8% loan. The answer before taxes is the same as that after taxes.

- 10.25** (a) Annual loan payment is the cost of the \$160,000 debt capital. First, determine the after-tax cost of debt capital.

$$\text{Debt cost of capital: before-tax } (1 - T_c) = 9\%(1 - 0.22) = 7.02\%$$

$$\text{Annual interest } 160,000(0.0702) = \$11,232$$

$$\text{Annual principal re-payment} = 160,000/15 = \$10,667$$

$$\text{Total annual payment} = \$21,899$$

- (b) Equity cost of capital: 6.5% per year on \$40,000 is \$2600 annually.

Set up the spreadsheet with the three series. Equity rate is 6.5%, loan interest rate is 7.02%, and principal re-payment rate is 6.5% since the annual amount will not earn interest at the equity rate of 6.5%. The difference in PW values is:

$$\begin{aligned} \text{Difference} &= 200,000 - \text{PW equity lost} - \text{PW of loan interest paid} \\ &\quad - \text{PW of loan principal re-payment not saved as equity} \\ &= \$-26,916 \end{aligned}$$

This means the PW of the selling price in the future must be at least \$26,916 more than the current purchase price to make a positive return on the investment, assuming all the current numbers remain stable.

- (c) After-tax WACC = $0.2(6.5\%) + 0.8(9\%)(1 - 0.22)$
= 6.916%

	A	B	C	D	E	F
1						
2			Equity (20%)	Debt portion (80%)		
3	Year		Lost interest CF	Loan interest CF	Prin repay CF	Difference in PW
4	Annual i value		6.50%	7.02%	6.50%	
5	PW amount	\$ 200,000	(\$24,447)	(\$102,171)	(\$100,298)	(\$26,916)
6	0	200000				
7	1		-2600	-11232	-10667	
8	2		-2600	-11232	-10667	
9	3		-2600	-11232	-10667	
10	4		-2600	-11232	-10667	
11	5		-2600	-11232	-10667	
12	6		-2600	-11232	-10667	
13	7		-2600	-11232	-10667	
14	8		-2600	-11232	-10667	
15	9		-2600	-11232	-10667	
16	10		-2600	-11232	-10667	
17	11		-2600	-11232	-10667	
18	12		-2600	-11232	-10667	
19	13		-2600	-11232	-10667	
20	14		-2600	-11232	-10667	
21	15		-2600	-11232	-10667	

10.26 Cost of equity capital = $10/(1 - 0.05)(130)$
= 8.1%

10.27 By Equation [10.7]

$$R_e = 0.92/23 + 0.032$$

$$= 0.072 \quad (7.2\%)$$

10.28 The two tax rates are the same for equity financing because stock dividends paid to stockholders and owners are not tax deductible like interest is for corporate debt.

10.29 $R_e = 0.032 + 1.41(0.038)$
= 0.0856 (8.56%)

10.30 Dividend method: $R_e = 0.75/11.50 + 0.03$
= 0.0952 (9.52%)

CAPM: $R_e = 0.055 + 1.3(0.03)$
= 0.094 (9.4%)

10.31 Dividend method: $R_e = DV_1/P + g$
= $0.93/18.80 + 0.015$
= 0.0644 (6.44%)

CAPM: (The return values are in percents)

$$R_e = R_f + \beta(R_m - R_f)$$

$$= 4.5 + 1.19(4.95 - 4.5)$$

$$= 5.04\%$$

CAPM estimate of cost of equity capital is 1.4% lower.

10.32 Last year CAPM computation: $R_e = 4.0 + 1.10(5.1 - 4.0)$
 $= 4.0 + 1.21 = 5.21\%$

This year CAPM computation: $R_e = 3.9 + 1.18(5.1 - 3.9)$
 $= 3.9 + 1.42 = 5.32\%$

Equity costs slightly more in part because the company's stock became more volatile based on an increase in beta. Also, the safe return rate decreased 0.1% in the switch from US to Euro bonds.

10.33 (a) Total equity and debt fund is \$15 million.

$$\begin{aligned}\text{Equity WACC} &= \text{retained earnings fraction (cost)} + \text{stock fraction (cost)} \\ &= 4/15(7.4\%) + 6/15(4.8\%) \\ &= 3.893\%\end{aligned}$$

$$\text{Debt WACC} = 5/15(9.8\%) = 3.267\%$$

$$\text{WACC} = 3.893 + 3.267 = 7.16\%$$

$$\begin{aligned}\text{MARR} &= \text{WACC} + 4\% \\ &= 7.16 + 4.0 \\ &= 11.16\%\end{aligned}$$

(b) Debt capital gets a tax break; equity does not.

$$\text{After-tax cost of debt} = 9.8\%(1 - 0.32) = 6.664\%$$

$$\begin{aligned}\text{After-tax WACC} &= \text{equity cost} + \text{debt cost} \\ &= 4/15(7.4\%) + 6/15(4.8\%) + 5/15(6.664\%) \\ &= 6.11\%\end{aligned}$$

$$\text{After-tax MARR} = 6.11 + 4.0 = 10.11\%$$

10.34 A large D-E mix over time is not healthy financially because this indicates that the person owns too small of a percentage of his or her own assets (equity ownership) and is risky for creditors and lenders. When the economy is in a 'tight money situation' additional cash and debt capital (loans, credit cards, etc.) will be hard to obtain and very expensive in terms of the interest rate charged.

10.35 If the D-E mix of the purchaser is too high after the buyout and large interest payments (debt service) are required, the new company's credit rating may be degraded. In the event that additional borrowed funds are needed, it may not be possible to obtain them. Available equity funds may have to be depleted to stay afloat or grow as competition challenges the combined companies. Such events may significantly weaken the economic standing of the company.

10.36 (a) First find cost of equity capital using CAPM, which is the MARR

$$R_e = 3.0 + 0.95(5.0) = 7.75\%$$

Find i^* on equity investment of \$250,000 and NCF of \$48,000

$$0 = -250,000 + 48,000(P/A, i^*, 7)$$

$$i^* = 8.0\% > 7.75\%$$

The venture is acceptable

(b) For 50% equity financing at 7.75% and 50% debt financing at 8%

$$\begin{aligned} WACC = MARR &= 0.50(7.75\%) + 0.50(8\%) \\ &= 7.875\% \end{aligned}$$

The venture is acceptable because $8.0\% > 7.875\%$

10.37 100% equity financing

MARR = 7.5% is known. Determine PW at the MARR

$$\begin{aligned} PW &= -250,000 + 30,000(P/A, 7.5\%, 15) \\ &= -250,000 + 30,000(8.82712) \\ &= -250,000 + 264,814 \\ &= \$14,814 \end{aligned}$$

Since $PW > 0$, 100% equity financing meets the MARR requirement

60%-40% D-E financing

$$\begin{aligned} \text{Loan principal} &= 250,000(0.60) = \$150,000 \\ \text{Loan payment} &= 150,000(A/P, 7\%, 15) \\ &= 150,000(0.10979) \\ &= \$16,469 \text{ per year} \end{aligned}$$

Cost of 60% debt capital is 7% for the loan.

$$\begin{aligned} WACC &= 0.4(7.5\%) + 0.6(7\%) = 7.2\% \\ MARR &= 7.2\% \end{aligned}$$

$$\begin{aligned} \text{Annual NCF} &= \text{project NCF} - \text{loan payment} \\ &= \$30,000 - 16,469 = \$13,531 \end{aligned}$$

$$\text{Amount of equity invested} = 250,000 - 150,000 = \$100,000$$

Calculate PW at the MARR on the basis of the committed equity capital.

$$\begin{aligned}PW &= -100,000 + 13,531(P/A, 7.2\%, 15) \\&= -100,000 + 13,531(8.99397) \\&= \$21,697\end{aligned}$$

Since $PW > 0$; a 60-40 D-E mix also meets the MARR requirement.

Conclusion: Both financing plans make the project economically attractive.

10.38 (a) Find cost of equity capital using CAPM.

$$R_e = 4\% + 1.22(5\%) = 10.1\%$$

$$MARR = 10.1\%$$

Find i^* on 50% equity investment.

$$0 = -5,000,000 + 1,350,000(P/A, i^*, 5)$$

$$i^* = 10.9\% \quad (\text{RATE on spreadsheet})$$

The investment is marginally acceptable since $i^* > MARR$ of 10.1%

(b) Determine WACC and set $MARR = WACC$. For 50% debt financing at 8%,

$$WACC = MARR = 0.5(8\%) + 0.5(10.1\%) = 9.05\%$$

The investment is acceptable, since $10.9\% > MARR$ of 9.05%

10.39 (a) Calculate the two WACC values for financing alternative 1 and 2

$$WACC_1 = 0.4(9\%) + 0.6(10\%) = 9.6\%$$

$$WACC_2 = 0.25(9\%) + 0.75(10.5\%) = 10.125\%$$

Use approach 1, with a D-E mix of 40%-60%

(b) Let x_1 and x_2 be the maximum costs of debt capital for each plan, respectively

$$\text{Alternative 1: } 10\% = WACC_1 = 0.4(9\%) + 0.6(x_1)$$

$$x_1 = 10.67\%$$

Debt capital cost could increase from 10% to 10.67%

$$\text{Alternative 2: } 10\% = WACC_2 = 0.25(9\%) + 0.75(x_2)$$

$$x_2 = 10.33\%$$

Debt capital cost would have to decrease from 10.5% to 10.33%

10.40 Two independent, revenue projects with different lives. Fastest solution is to find AW at MARR for each project. Select all those with $AW > 0$. Find WACC first.

Equity capital is 40% at a cost of 7.5% per year

Debt capital is 5% per year, compounded quarterly. Effective rate after taxes is

$$\begin{aligned} \text{After-tax debt } i^* &= [(1 + 0.05/4)^4 - 1] (1 - 0.3) (100\%) \\ &= 5.095(0.7) = 3.566\% \text{ per year} \end{aligned}$$

$$\text{WACC} = 0.4(7.5\%) + 0.6(3.566\%) = 5.14\% \text{ per year}$$

$$\text{MARR} = \text{WACC} = 5.14\%$$

	A	B	C	D	E	F	G
1		MARR =	5.14%	7.14%			
2							
3		Project W	Project R				
4	Year	NCF	NCF				
5	0	\$ (250,000)	\$ (125,000)				
6	1	\$ 48,000	\$ 30,000				
7	2	\$ 48,000	\$ 30,000				
8	3	\$ 48,000	\$ 30,000				
9	4	\$ 48,000	\$ 30,000				
10	5	\$ 48,000	\$ 30,000				
11	6	\$ 48,000					
12	7	\$ 48,000					
13	8	\$ 48,000					
14	9	\$ 48,000					
15	10	\$ 48,000					
16							
17	AW @ MARR	\$ 15,403	\$ 1,016				
18	overall i^*	14.04%	6.40%				
19							
20	AW @ 2% higher	\$ 12,175	\$ (601)				

(a) At $\text{MARR} = 5.14\%$, select both independent projects (row 17)

(b) At $i^* = 14.04\%$, project W is acceptable since it returns substantially more than 2% above $\text{MARR} = 5.14\%$. However, project R has a return of 6.40%. If the 2% risk assessment is realistic and imposed, project R is not acceptable based on too much risk.

10.41 (a) Stan: Stock value increase: $0.10(20,000) = \$2000$
Equity value at year-end: \$22,000 or a 10% increase

Theresa: Condo value increase: $0.10(100,000) = \$10,000$
Equity value at year-end: \$30,000 or a 50% increase

(b) Stan: Stock value decrease: $-0.10(20,000) = \$-2000$
Equity value at year-end: \$18,000 or a 10% increase

Theresa: Condo value decrease: $-0.10(100,000) = \$-10,000$
Equity value at year-end: \$10,000 or a 50% decrease

(c) Under high leverage situations, the gain or loss is multiplied by the leverage factor. If the investment goes down a small amount, the high leverage loses much more than the unleveraged investment (\$2000 loss for Stan vs. a \$10,000 loss for Teresa). With gains, the return on equity capital is much larger for the highly leverage investment, but it may be much more risky.

10.42 $W_i = 1/8 = 0.125$

10.43 $\sum s_i = 60 + 40 + 80 + 30 + 20 = 230$

$W_1 = 60/230 = 0.26$
 $W_2 = 40/230 = 0.17$
 $W_3 = 80/230 = 0.35$
 $W_4 = 30/230 = 0.13$
 $W_5 = 20/230 = 0.09$ (Sum is 1.00)

10.44 $S = 1 + 2 + 3 + \dots + 10 = 10(11)/2 = 55$

(a) $W_C = 3/55 = 0.055$

(b) $W_J = 10/55 = 0.182$

10.45 Ratings by attribute with 100 for most important.

Logic: $F = 100$
 $U = \frac{1}{2} F = 50$
 $S = 0.7 U = 0.7(50) = 35$
 $R = 2S = 2(35) = 70$

<u>Attribute</u>	<u>Importance Score</u>
F	100
S	35
U	50
R	<u>70</u>
	255

Weighting, $W_i = \text{Score}/255$

<u>Attribute</u>	<u>W_i</u>
F	0.39
S	0.14
U	0.20
R	<u>0.27</u>
	1.00

10.46 Ratings by attribute with 100 for most important.

Logic: #1 = $0.90(\#5) = 0.90(100) = 90$
 #2 = $0.10(100) = 10$
 #3 = $0.30(100) = 30$
 #4 = $2(\#3) = 2(30) = 60$
 #5 = 100
 #6 = $0.80(\#4) = 0.80(60) = 48$

<u>Attribute</u>	<u>Importance</u>
1	9
2	1
3	3
4	6
5	10
6	<u>4.8</u>
	33.8

Weighting, $W_i = \text{Score}/33.8$

<u>Attribute</u>	<u>W_i</u>
1	$9/33.8 = 0.27$
2	$1/33.8 = 0.03$
3	$3/33.8 = 0.09$
4	$6/33.8 = 0.18$
5	$10/33.8 = 0.30$
6	$4.8/33.8 = 0.14$

10.47 Calculate W_i = importance score/sum and solve for R_j

Vice president

Attribute, i	Importance score	W_i	<u>V_{ij} values</u>		
			1	2	3
1	20	0.10	5	7	10
2	80	0.40	40	24	12
3	<u>100</u>	0.50	<u>50</u>	<u>20</u>	<u>25</u>
	Sum = 200		95	51	47 = R_j values

Select alternative 1 since R_1 is largest.

Assistant vice president

Attribute, i	Importance score	W_i	<u>V_{ij} values</u>		
			1	2	3
1	100	0.50	25	35	50
2	80	0.40	40	24	12
3	<u>20</u>	0.10	<u>10</u>	<u>4</u>	<u>5</u>
	Sum = 200		75	63	67 = R_j values

With $R_1 = 75$, select alternative 1

Results are the same, even though the VP and Asst. VP rated opposite on factors 1 and 3. High score on attribute 1 by Asst. VP is balanced by the VP's score on attributes 2 and 3.

10.48 (a) Select A since PW_A is larger.

(b) Calculate R_j and use *manager* scores for attributes.

$$W_i = \frac{\text{Importance score}}{\text{Sum}}$$

Attribute, i	Importance by manager	W_i	<u>R_j</u>	
			A	B
1	80	0.48	0.48	0.43
2	35	0.21	0.07	0.21
3	30	0.18	0.18	0.16
4	<u>20</u>	0.12	<u>0.03</u>	<u>0.12</u>
	165		0.76	0.92

Therefore, select B

(c) Calculate R_j and use *trainer* scores for attributes.

Attribute <u>i</u>	Importance (by trainer) W_i	<u>R_j</u>	
		A	B
1	80	0.26	0.23
2	80	0.09	0.26
3	100	0.32	0.29
4	<u>50</u>	<u>0.04</u>	<u>0.16</u>
	310	0.71	0.94

Select B

Conclusion: 2 methods indicate B and 1, the PW method, indicates A

10.49 Answer is (c)

10.50 Answer is (b)

10.51 Answer is (a)

10.52 Answer is (b)

10.53 Equity = $41/71 = 57.7\%$
Debt = $30/71 = 42.3\%$

Answer is (d)

10.54 WACC = $5/10(13.7) + 2/10(8.9) + 3/10(7.8)$
= 10.97%

Answer is (c)

10.55 Before-tax ROR = after-tax ROR / $(1 - T_e)$
= $11.2\% / (1 - 0.39)$
= 18.4%

Answer is (c)

10.56 Historical WACC = $0.5(11\%) + 0.5(9\%) = 10\%$

Let x = cost of equity capital

WACC = equity fraction(cost of equity) + fraction of debt(cost of debt)

$$10\% = 0.25(x) + 0.75[9\%(1.2)]$$

$$x = (10 - 8.1)/0.25 = 7.6\%$$

Answer is (a)

$$\mathbf{10.57} \quad \Sigma s_i = 55 + 45 + 85 + 30 + 60 = 275$$

$$W_1 = 55/275 = 0.20$$

Answer is (b)

$$\mathbf{10.58} \quad S = 1 + 2 + 3 + \dots + 8 = 8(9)/2 = 36$$

$$W_C = 6/36 = 0.166$$

Answer is (a)

Solution to Case Study, Chapter 10

There is not always a definitive answer to case study exercises. Here are example responses

WHICH IS BETTER - DEBT OF EQUITY FINANCING?

1. Set MARR = WACC

$$\text{WACC} = (\% \text{ equity})(\text{cost of equity}) + (\% \text{ debt})(\text{cost of debt})$$

Equity: Use Eq. [10.7]

$$R_e = \frac{0.50}{15} + 0.05 = 8.33\%$$

Debt: Interest is tax deductible; use Eqs. [10.5] and [10.6].

$$\begin{aligned} \text{Tax savings} &= \text{interest}(\text{tax rate}) \\ &= [\text{loan payment} - \text{principal portion}](\text{tax rate}) \end{aligned}$$

$$\text{Loan payment} = 750,000(A/P, 8\%, 10) = \$111,773 \text{ per year}$$

$$\text{Interest} = 111,773 - 75,000 = \$36,773$$

$$\text{Tax savings} = (36,773)(0.35) = \$12,870$$

Cost of debt capital is i^* from a PW relation:

$$\begin{aligned} 0 &= \text{loan amount} - (\text{annual payment after taxes})(P/A, i^*, 10) \\ &= 750,000 - (111,773 - 12,870)(P/A, i^*, 10) \end{aligned}$$

$$(P/A, i^*, 10) = 750,000 / 98,903 = 7.5832$$

$$i^* = 5.37\% \quad (\text{RATE function})$$

$$\text{Plan A (50-50): } \text{MARR} = \text{WACC}_A = 0.5(5.37) + 0.5(8.33) = 6.85\%$$

$$\text{Plan B (0-100%): } \text{MARR} = \text{WACC}_B = 8.33\%$$

2. A: 50-50 D-E financing

Use relations in case study statement and the results from Question #1.

$$\text{TI} = 300,000 - 36,773 = \$263,227$$

$$\text{Taxes} = 263,227(0.35) = \$92,130$$

$$\begin{aligned} \text{After-tax NCF} &= 300,000 - 75,000 - 36,773 - 92,130 \\ &= \$96,097 \end{aligned}$$

Find plan i_A^* from AW relation for \$750,000 of equity capital

$$0 = (\text{committed equity capital})(A/P, i_A^*, n) + S(A/F, i_A^*, n) + \text{after tax NCF}$$

$$0 = -750,000(A/P, i_A^*, 10) + 200,000(A/F, i_A^*, 10) + 96,097$$

$$i_A^* = 7.67\% \quad (\text{RATE function})$$

Since $7.67\% > WACC_A = 6.85\%$, plan A is acceptable.

B: 0–100 D–E financing

Use relations is the case study statement

$$\text{After tax NCF} = 300,000(1 - 0.35) = \$195,000$$

All \$1.5 million is committed. Find i_B^*

$$0 = -1,500,000(A/P, i_B^*, 10) + 200,000(A/F, i_B^*, 10) + 195,000$$

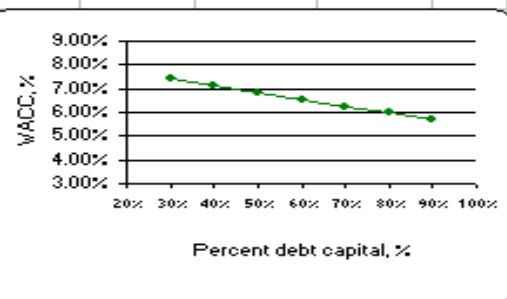
$$i_B^* = 6.61\% \quad (\text{RATE function})$$

Now $6.61\% < WACC_B = 8.33\%$, plan B is rejected.

Recommendation: Select plan A with 50-50 financing.

- Spreadsheet shows the hard way (develops debt-related cash flows for each year) and the easy way (uses costs of capital from #1) to plot WACC. It is shaped differently than the WACC curve in Figure 10-2.

	A	B	C	D	E	F	G	H
1		Question #3 (The hard way)						
2								
3	Capital investment	\$ 1,500,000						
4	Cost of equity capital	8.33%						
5	Tax rate	35%						
6								
7								
8		Cost of debt capital						
9	% debt	Loan amount	Loan payment	Interest amount	Tax savings	Loan cash flow	Cost of debt	WACC
10	0.00001%	\$ 0.15	\$ 0.02	\$ 0.01	\$ 0.00	\$ 0.02	5.37%	8.33%
11	30%	\$ 450,000	\$ 67,063	\$ 22,063	\$ 7,722	\$ 59,341	5.37%	7.44%
12	40%	\$ 600,000	\$ 89,418	\$ 29,418	\$ 10,296	\$ 79,122	5.37%	7.15%
13	50%	\$ 750,000	\$ 111,772	\$ 36,772	\$ 12,870	\$ 98,902	5.37%	6.85%
14	60%	\$ 900,000	\$ 134,127	\$ 44,127	\$ 15,444	\$ 118,682	5.37%	6.56%
15	70%	\$ 1,050,000	\$ 156,481	\$ 51,481	\$ 18,018	\$ 138,463	5.37%	6.26%
16	80%	\$ 1,200,000	\$ 178,835	\$ 58,835	\$ 20,592	\$ 158,243	5.37%	5.97%
17	90%	\$ 1,350,000	\$ 201,190	\$ 66,190	\$ 23,166	\$ 178,023	5.37%	5.67%
18								
19								
20		Question #3 (The easy way)						
21								
22								
23	Cost of debt capital =	5.37%						
24	Cost of equity capital =	8.33%						
25								
26	% debt	WACC						
27	0%	8.33%						
28	30%	7.44%						
29	40%	7.15%						
30	50%	6.85%						
31	60%	6.55%						
32	70%	6.26%						
33	80%	5.96%						
34	90%	5.67%						



Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 11
Replacement and Retention Decisions

11.1 In taking a non-owner's viewpoint, the analysis is done from the perspective of someone who does not own *any* of the assets under consideration. This means that in order to acquire the presently-owned asset, the consultant would have to "buy" it at its fair market value. The costs associated with doing so would thus represent the true cost of keeping the presently-owned asset.

11.2 $BV_3 = 100,000 - 3(20,000) = \$40,000$

$$\begin{aligned}\text{Sunk cost} &= 40,000 - 15,000 \\ &= \$25,000\end{aligned}$$

11.3 (a)x This type of thinking is improperly penalizing the challenger (Dodge Charger) because he wants that deal to make up for the past bad investment he made in buying the Shelby. In doing so, he is likely to miss out on what would have been a very profitable situation in buying the Charger.

(b) The sunk cost is the difference between the amount he has invested in the Shelby and its current market value.

$$\begin{aligned}\text{Sunk cost} &= 115,000 - 126,000 \\ &= \$11,000\end{aligned}$$

11.4 The assumptions are:

- (1) The services provided are needed for the indefinite future.
- (2) The challenger is the best available challenger now and in the future. When this challenger replaces the defender (now or later), it will be repeated in succeeding life cycles.
- (3) Cost estimates for every life cycle of the defender and challenger will be the same, unless otherwise specified.

11.5 $P = \text{market value} = \$39,000$
 $AOC = \$17,000 \text{ per year}$
 $n = 3 \text{ years}$
 $S = \$23,000$

11.6 (a) $P = 90,000 - 8000(2) = \$74,000$
 $S = 90,000 - 8000(3) = \$66,000$
 $AOC = \$65,000 \text{ per year}$

$$\begin{aligned}
 \text{(b)} \quad P &= 90,000 - 8000(3) = \$66,000 \\
 S &= 90,000 - 8000(4) = \$58,000 \\
 \text{AOC} &= \$65,000 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 \text{11.7} \quad P &= 7000 + 17,000 = \$24,000 \\
 S &= \$12,000 \\
 \text{AOC} &= \$27,000 \text{ per year} \\
 n &= 3 \text{ years}
 \end{aligned}$$

$$\begin{aligned}
 \text{11.8} \quad \text{AW}_1 &= -10,000(A/P, 10\%, 1) - 1000 + 7000(A/F, 10\%, 1) = \$-5000 \\
 \text{AW}_2 &= -10,000(A/P, 10\%, 2) - 1000(P/F, 10\%, 1)(A/P, 10\%, 2) \\
 &\quad + (5000 - 1200)(A/F, 10\%, 2) = \$-4476 \\
 \text{AW}_3 &= -10,000(A/P, 10\%, 3) - [1000(P/F, 10\%, 1) + 1200(P/F, 10\%, 2)](A/P, 10\%, 3) \\
 &\quad + (4500 - 1300)(A/F, 10\%, 3) = \mathbf{\$-3819} \\
 \text{AW}_4 &= -10,000(A/P, 10\%, 4) - [1000(P/F, 10\%, 1) + 1200(P/F, 10\%, 2) \\
 &\quad + 1300(P/F, 10\%, 3)](A/P, 10\%, 4) + (3000 - 2000)(A/F, 10\%, 4) = \$-3847 \\
 \text{AW}_5 &= -10,000(A/P, 10\%, 5) - [1000(P/F, 10\%, 1) + 1200(P/F, 10\%, 2) \\
 &\quad + 1300(P/F, 10\%, 3) + 2000(P/F, 10\%, 4)](A/P, 10\%, 5) \\
 &\quad + (2000 - 3000)(A/F, 10\%, 5) = \$-3921
 \end{aligned}$$

ESL is 3 years with AW = \$-3819 per year

11.9 (a) Find total AW for each year of ownership

$$\begin{aligned}
 \text{AW}_1 &= -345,000(A/P, 10\%, 1) - 148,000 + 140,000(A/F, 10\%, 1) = \$-387,500 \\
 \text{AW}_2 &= -345,000(A/P, 10\%, 2) - 148,000 + 140,000(A/F, 10\%, 2) = \$-280,119 \\
 \text{AW}_3 &= -345,000(A/P, 10\%, 3) - 148,000 + 140,000(A/F, 10\%, 3) = \mathbf{\$-244,434} \\
 \text{AW}_4 &= -345,000(A/P, 10\%, 4) - 148,000(P/A, 10\%, 3)(A/P, 10\%, 4) \\
 &\quad - 210,000(P/F, 10\%, 4)(A/P, 10\%, 4) = \$-270,197 \\
 \text{AW}_5 &= -345,000(A/P, 10\%, 5) - 148,000(P/A, 10\%, 3)(A/P, 10\%, 5) \\
 &\quad - 210,000(P/A, 10\%, 2)(P/F, 10\%, 3)(A/P, 10\%, 5) = \$-260,337 \\
 \text{AW}_6 &= -345,000(A/P, 10\%, 5) - 148,000(P/A, 10\%, 3)(A/P, 10\%, 6) \\
 &\quad - 210,000(P/A, 10\%, 3)(P/F, 10\%, 3)(A/P, 10\%, 6) = \$-253,813
 \end{aligned}$$

ESL is 3 years with AW = \$-244,434

(b) If retained 5 years, AW = \$260,337 per year, which is a 6.5% increase

$$\text{Percent increase} = (260,337 - 244,434)/244,434 = 0.065 \quad (6.5\%)$$

$$\begin{aligned}
 \text{11.10} \quad \text{For P: } 18,899 &= P(A/P, 10\%, 3) \\
 18,899 &= P(0.40211) \\
 P &= \$47,000
 \end{aligned}$$

$$\begin{aligned}\text{For S: } 6648 &= S(A/F, 10\%, 3) \\ 6648 &= S(0.30211) \\ S &= \$22,005\end{aligned}$$

11.11 Amortization of a \$70,000,000 investment at 8% per year is constant at \$-5,600,000. Therefore, only consider maintenance cost:

$$\begin{aligned}AW_1 &= -83,000(A/F, 8\%, 1) = \$-83,000 \\ AW_2 &= -91,000(A/F, 8\%, 2) = \$-43,750 \\ AW_3 &= -125,000(A/F, 8\%, 3) = \mathbf{\$-38,504} \\ AW_4 &= -183,000(A/F, 8\%, 4) = \$-40,612\end{aligned}$$

Lowest AW is for 3 years; maintenance should be scheduled at 3-year intervals

11.12

$$\begin{aligned}AW_1 &= -65,000(A/P, 10\%, 1) - 50,000 + 30,000(A/F, 10\%, 1) = \$-91,500 \\ AW_2 &= -65,000(A/P, 10\%, 2) - [50,000 + 10,000(A/G, 10\%, 2)] + 30,000(A/F, 10\%, 2) \\ &= \mathbf{\$-77,929} \\ AW_3 &= -65,000(A/P, 10\%, 3) - [50,000 + 10,000(A/G, 10\%, 3)] + 20,000(A/F, 10\%, 3) \\ &= \$-79,461 \\ AW_4 &= -65,000(A/P, 10\%, 4) - [50,000 + 10,000(A/G, 10\%, 4)] + 20,000(A/F, 10\%, 4) \\ &= \$-80,008 \\ AW_5 &= -65,000(A/P, 10\%, 5) - [50,000 + 10,000(A/G, 10\%, 5)] + 20,000(A/F, 10\%, 5) \\ &= \$-81,972 \\ AW_6 &= -65,000(A/P, 10\%, 6) - [50,000 + 10,000(A/G, 10\%, 6)] + 20,000(A/F, 10\%, 6) \\ &= \$-84,568 \\ AW_7 &= -65,000(A/P, 10\%, 7) - [50,000 + 10,000(A/G, 10\%, 7)] + 20,000(A/F, 10\%, 7) \\ &= \$-87,459\end{aligned}$$

ESL is 2 years with AW = \$-77,929

11.13 (a) Use 1 year and AW of first cost P

$$\begin{aligned}-88,000 &= -80,000(A/P, i, 1) \\ (A/P, i, 1) &= 1.1000\end{aligned}$$

From tables, $i = 10\%$ per year

(b) $-78,762 = -46,095 - 46,000 + \text{AW of S}$

$$\begin{aligned}\text{AW of S} &= 13,333 = S(A/F, 10\%, 2) \\ 13,333 &= S(0.47619) \\ S &= \$27,999 \quad (\text{basically, } \$28,000)\end{aligned}$$

11.14

$$\begin{aligned}AW_1 &= -70,000(A/P, 12\%, 1) - 75,000 + 59,500(A/F, 12\%, 1) = \$-93,900 \\ AW_2 &= -70,000(A/P, 12\%, 2) - 75,000 + 50,575(A/F, 12\%, 2) = \$-92,563 \\ AW_3 &= -70,000(A/P, 12\%, 3) - 75,000 + 42,989(A/F, 12\%, 3) = \$-91,405 \\ AW_4 &= -70,000(A/P, 12\%, 4) - 75,000 + 36,540(A/F, 12\%, 4) = \$-90,401\end{aligned}$$

$$AW_5 = -70,000(A/P, 12\%, 5) - 75,000 + 31,059(A/F, 12\%, 5) = \$-89,530$$

$$AW_6 = -70,000(A/P, 12\%, 6) - 75,000 + 26,400(A/F, 12\%, 6) = \mathbf{\$-88,773}$$

ESL is 6 years with $AW = \$-88,773$ per year

11.15 (a) Solution by hand using regular AW computations

Year	Salvage Value, \$	AOC, \$ per year
1	100,000	70,000
2	80,000	80,000
3	60,000	90,000
4	40,000	100,000
5	20,000	110,000
6	0	120,000
7	0	130,000

$$AW_1 = -150,000(A/P, 15\%, 1) - 70,000 + 100,000(A/F, 15\%, 1) = \$-142,500$$

$$AW_2 = -150,000(A/P, 15\%, 2) - [70,000 + 100,000(A/G, 15\%, 2)] + 80,000(A/F, 15\%, 2) = \$-129,709$$

$$AW_3 = \mathbf{\$-127,489}$$

$$AW_4 = \$-127,792$$

$$AW_5 = \$-129,009$$

$$AW_6 = \$-130,608$$

$$AW_7 = \$-130,552$$

ESL = 3 years with $AW_3 = \$-127,489$

(b) Spreadsheet screen shot utilizes the annual marginal costs to determine that ESL is 3 years with $AW = \$-127,489$.

	A	B	C	D	E	F	G
1							
2		Market	Loss in MV	Lost interest		MC for	AW of
3	Year	value	for year	MV for year	AOC	year	marginal cost
4	0	\$ 150,000					
5	1	\$ 100,000	\$ 50,000	\$ 22,500	\$ 70,000	\$ 142,500	\$ (142,500)
6	2	\$ 80,000	\$ 20,000	\$ 15,000	\$ 80,000	\$ 115,000	\$ (129,709)
7	3	\$ 60,000	\$ 20,000	\$ 12,000	\$ 90,000	\$ 122,000	\$ (127,489)
8	4	\$ 40,000	\$ 20,000	\$ 9,000	\$ 100,000	\$ 129,000	\$ (127,792)
9	5	\$ 20,000	\$ 20,000	\$ 6,000	\$ 110,000	\$ 136,000	\$ (129,009)
10	6	\$ -	\$ 20,000	\$ 3,000	\$ 120,000	\$ 143,000	\$ (130,607)
11	7	\$ -	\$ -	\$ -	\$ 130,000	\$ 130,000	\$ (130,553)
12							
13							
14			=0.15*\$B9			=SUM(C11:E11)	
15							

11.16 Set up AW equations for $n = 1$ through 7 and solve by hand.

$$AW_1 = -100,000(A/P, 14\%, 1) - 28,000 + 75,000(A/F, 14\%, 1) = \$-67,000$$

$$AW_2 = -100,000(A/P, 14\%, 2) - [28,000(P/F, 14\%, 1) + 31,000(P/F, 14\%, 2)](A/P, 14\%, 2) + 60,000(A/F, 14\%, 2) = \$-62,093$$

$$AW_3 = \$-59,275$$

$$AW_4 = \$-57,594$$

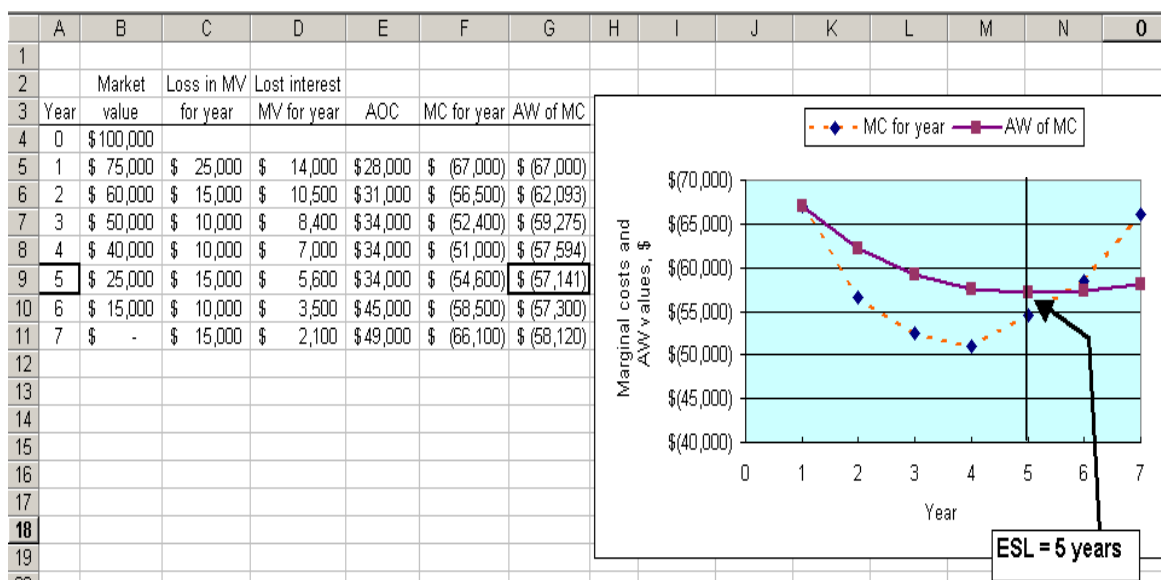
$$AW_5 = \mathbf{\$-57,141}$$

$$AW_6 = \$-57,300$$

$$AW_7 = \$-58,120$$

Economic service life is 5 years with $AW = \$-57,141$ per year

11.17 Spreadsheet and marginal costs used to find the ESL of 5 years with $AW = \$-57,141$



11.18 (a) The three estimate changes are made in the spreadsheet: increase to \$4 million for heating element exchange in year 5; market value retention of only 50% starting with year 5; and, increases of 25% per year in maintenance cost starting in year 5.

PE

	A	B	C	D	E	F
1	Interest rate	15%			First cost, \$ million	38.00
2		Market	AOC	Capital	AW of AOC,	Total AW,
3	Year	Value, \$	\$/year	Recovery, \$/year	\$/year	\$/year
4	1	25.00	-3.40	-18.70	-3.40	-22.10
5	2	18.75	-3.74	-14.65	-3.56	-18.21
6	3	14.06	-4.11	-12.59	-3.72	-16.31
7	4	10.55	-4.53	-11.20	-3.88	-15.08
8	5	5.27	-5.66	-10.55	-4.14	-14.70
9	6	2.64	-11.07	-9.74	-4.93	-14.67
10	7	1.32	-8.84	-9.01	-5.29	-14.30
11	8	0.66	-11.05	-8.42	-5.71	-14.13
12	9	0.33	-13.81	-7.94	-6.19	-14.13
13	10	0.16	-17.26	-7.56	-6.74	-14.30
14	11	0.08	-21.58	-7.26	-7.34	-14.60
15	12	0.04	-26.97	-7.01	-8.02	-15.03
16						
17		Value retains 50% as of year 5	AOC increases by 25% as of year 5; extra cost is \$4M in year 6			

Results are significantly different. ESL is now 8 or 9 years, with a flat AW curve for several years.

- (b) ESL has decreased from 12 to 8 or 9 years (about a 25 to 33% decrease); AW of costs has increased from \$12.32 to \$14.13 million per year, which is an annual increase of 14.7%.

11.19 (a) If the year is n_D , replace the defender, (b) if the year is not n_D , retain the defender for another year and then do another one-year later analysis, (c) if the estimates have changed, update all values and initiate a new replacement study.

11.20 (a) Purchase the challenger today because its AW of \$-48,000 is lower than the AW of the defender for any number of years of retention.

(b) Reevaluate in 2 years.

$$\begin{aligned}
 \mathbf{11.21} \quad AW_D &= -(100,000 + 20,000)(A/P, 20\%, 4) + 40,000(A/F, 20\%, 4) \\
 &= -120,000(0.38629) + 40,000(0.18629) \\
 &= \$-38,903
 \end{aligned}$$

$$\begin{aligned}
 AW_C &= -270,000(A/P, 20\%, 10) + 50,000(A/F, 20\%, 10) \\
 &= -270,000(0.23852) + 50,000(0.03852) \\
 &= \$-62,474
 \end{aligned}$$

Select the defender; upgrade rooms and plan to keep them for 4 years.

$$\begin{aligned}
 \mathbf{11.22} \quad AW_D &= -(9000 + 25,000)(A/P, 10\%, 3) - 47,000 + 22,000(A/F, 10\%, 3) \\
 &= -(34,000)(0.40211) - 47,000 + 22,000(0.30211) \\
 &= \$54,025
 \end{aligned}$$

$$\begin{aligned} 11.23 \quad AW_C &= -26,000(A/P, 10\%, 5) - 1200 + 8000(A/F, 10\%, 5) \\ &= \$-6748 \end{aligned}$$

$$\begin{aligned} AW_1 &= -5000(A/P, 10\%, 1) - 1900 + 3000(A/F, 10\%, 1) \\ &= \$-4400 \end{aligned}$$

$$\begin{aligned} AW_2 &= -5000(A/P, 10\%, 2) - [1900 + 200(A/G, 10\%, 2)] + 2500(A/F, 10\%, 2) \\ &= \$-3686 \end{aligned}$$

$$\begin{aligned} AW_3 &= -5000(A/P, 10\%, 3) - [1900 + 200(A/G, 10\%, 3)] + 2200(A/F, 10\%, 3) \\ &= \$-3433 \end{aligned}$$

Lowest AW is at three years (defender). Therefore, keep the defender three years and then replace it with a used vehicle just like the one that is currently owned.

$$\begin{aligned} 11.24 \quad AW_D &= -25,000(A/P, 15\%, 5) - 180,000 \\ &= \$-187,458 \end{aligned}$$

$$\begin{aligned} AW_C &= -700,000(A/P, 15\%, 10) - 70,000 + 50,000(A/F, 15\%, 10) \\ &= \$-207,014 \end{aligned}$$

Select the defender; retain the current process

$$\begin{aligned} 11.25 \quad AW_{D1} &= -(8000 + 43,000)(A/P, 10\%, 1) - 22,000 + 8000(A/F, 10\%, 1) \\ &= \$-70,100 \end{aligned}$$

$$\begin{aligned} AW_{D2} &= -(8000 + 43,000)(A/P, 10\%, 2) - 22,000(P/F, 10\%, 1)(A/P, 10\%, 2) \\ &\quad + (8000 - 25,000)(A/F, 10\%, 2) \\ &= \$-49,005 \end{aligned}$$

$$AW_C = \$-47,063$$

The company should replace the existing machine *now*.

11.26 Defender estimates have changed; determine the ESL for the defender

$$\begin{aligned} AW_{D1} &= -50,000(A/P, 10\%, 1) - 37,000 + 10,000(A/F, 10\%, 1) \\ &= -50,000(1.1) - 37,000 + 10,000(1.0) \\ &= \$-82,000 \end{aligned}$$

$$\begin{aligned} AW_{D2} &= -50,000(A/P, 10\%, 2) - 37,000 + 1000(A/F, 10\%, 2) \\ &= -50,000(0.57619) - 37,000 + 1000(0.47619) \\ &= \$-65,333 \end{aligned}$$

ESL is 2 years with $AW_D = \$-65,333$

$$AW_C = \$-56,000$$

The company should outsource the process now

$$\begin{aligned}
11.27 \text{ } AW_D &= -25,000(A/P, 10\%, 1) - 15,000 + 14,000(A/F, 10\%, 1) \\
&= -25,000(1.10) - 15,000 + 14,000(1.00) \\
&= \$-28,500
\end{aligned}$$

11.28 Find AW of defender for keeping one or two more years and compare against AW of challenger

$$\begin{aligned}
AW_{D1} &= -54,000(A/P, 10\%, 1) - 23,000 + 40,000(A/F, 10\%, 1) \\
&= -54,000(1.10) - 23,000 + 40,000 \\
&= \$-42,400
\end{aligned}$$

$$\begin{aligned}
AW_{D2} &= -54,000(A/P, 10\%, 2) - 23,000 + 20,000(A/F, 10\%, 2) \\
&= -54,000(0.57619) - 23,000 + 20,000(0.47619) \\
&= \$-44,590
\end{aligned}$$

$$\begin{aligned}
AW_C &= -138,000(A/P, 10\%, 5) - 9,000 + 32,000(A/F, 10\%, 5) \\
&= -138,000(0.26380) - 9,000 + 32,000(0.16380) \\
&= \$-40,163
\end{aligned}$$

Replace the defender with the challenger now

11.29 Determine cost of keeping defender one, two, or three more years and compare to cost of challenger:

$$\begin{aligned}
AW_{D1} &= -30,000(A/P, 10\%, 1) - 24,000 + 25,000(A/F, 10\%, 1) \\
&= -30,000(1.10) - 24,000 + 25,000 \\
&= \$-32,000
\end{aligned}$$

$$\begin{aligned}
AW_{D2} &= -30,000(A/P, 10\%, 2) - [24,000 + 1000(A/G, 10\%, 2)] + 14,000(A/F, 10\%, 2) \\
&= -30,000(0.57619) - [24,000 + 1000(0.4762)] + 14,000(0.47619) \\
&= \$-35,095
\end{aligned}$$

$$\begin{aligned}
AW_{D3} &= -30,000(A/P, 10\%, 3) - [24,000 + 1000(A/G, 10\%, 3)] + 10,000(A/F, 10\%, 3) \\
&= -30,000(0.40211) - [24,000 + 1000(0.9366)] + 10,000(0.30211) \\
&= \$-33,979
\end{aligned}$$

If defender is replaced now, $AW_C = \$-33,000$

If defender is replaced one or two years from now, $AW_C = \$-35,000$

Keep defender one year and replace with similar defender

$$\begin{aligned}
11.30 \text{ } AW_D &= -(50,000 + 200,000)(A/P, 12\%, 3) + 40,000(A/F, 12\%, 3) \\
&= -250,000(0.41635) + 40,000(0.29635) \\
&= \$-92,234
\end{aligned}$$

$$\begin{aligned}
 AW_C &= -300,000(A/P, 12\%, 10) + 50,000(A/F, 12\%, 10) \\
 &= -300,000(0.17698) + 50,000(0.05698) \\
 &= \$-50,245
 \end{aligned}$$

Purchase the challenger now; plan to keep then for 10 years, unless a better challenger is proposed in the meantime.

- 11.31** Use Goal Seek to find the breakeven defender cost of \$149,154. With the appraised market value of \$50,000, the upgrade maximum to select the defender is: Upgrade first cost to break even is $149,154 - 50,000 = \$99,154$

This is a maximum; any amount less than \$99,154 will indicate selection of the upgraded current system.

	A	B	C
1	Year	Defender	Challenger
2	0	-149,154	-300,000
3	1	0	0
4	2	0	0
5	3	40,000	0
6	4		0
7	5		0
8	6		0
9	7		0
10	8		0
11	9		0
12	10		50,000
13	AW before Goal Seek	-92,233	-50,246
14	AW after Goal Seek	-50,246	-50,246

Goal Seek

Set cell:

To value:

By changing cell:

OK Cancel

- 11.32** (a) By hand: Find ESL of the defender; compare with AW_C over 5 years.

$$\begin{aligned}
 AW_{D1} &= -8000(A/P, 15\%, 1) - 50,000 + 6000(A/F, 15\%, 1) \\
 &= -8000(1.15) - 44,000 \\
 &= \$-53,200
 \end{aligned}$$

$$\begin{aligned}
 AW_{D2} &= -8000(A/P, 15\%, 2) - 50,000 + (-3000 + 4000)(A/F, 15\%, 2) \\
 &= -8000(0.61512) - 50,000 + 1000(0.46512) \\
 &= \$-54,456
 \end{aligned}$$

$$\begin{aligned}
 AW_{D3} &= -8000(A/P, 15\%, 3) - [50,000(P/F, 15\%, 1) + \\
 &\quad 53,000(P/F, 15\%, 2)](A/P, 15\%, 3) + (-60,000 + \\
 &\quad 1000)(A/F, 15\%, 3) \\
 &= -8000(0.43798) - [50,000(0.8696) + 53,000(0.7561)] \\
 &\quad (0.43798) - 59,000(0.28798) \\
 &= \$-57,089
 \end{aligned}$$

The ESL is now 1 year with $AW_{D1} = \$-53,200$

$$\begin{aligned}
 AW_C &= -125,000(A/P, 15\%, 5) - 31,000 + 10,000(A/F, 15\%, 5) \\
 &= -125,000(0.29832) - 31,000 + 10,000(0.14832) \\
 &= \$-66,807
 \end{aligned}$$

Since the ESL AW_{D1} value is lower than the challenger AW_C , Richter should keep the defender now and replace it after 1 year.

- (b) By spreadsheet: In order to obtain the defender ESL of 1 year, first enter market values for each year in column B and AOC estimates in column C. Columns D determines annual CR using the PMT function, and AW of AOC values are calculated in column E using the PMT function with an imbedded NPV function. To make the decision, compare AW values.

$AW_D = \$-53,200$ at ESL of 1 year

$AW_C = \$-66,806$

Select the defender now and replace it after one year.

	A	B	C	D	E	F	G	H	I	J
1	i =	15%								
2	P =	\$8,000								
3				Defender Analysis						
4		Market								
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW				
6	1	\$ 6,000	\$ (50,000)	\$ (3,200)	\$ (50,000)	(53,200)		ESL		
7	2	\$ 4,000	\$ (53,000)	\$ (3,060)	\$ (51,395)	\$ (54,456)				
8	3	\$ 1,000	\$ (60,000)	\$ (3,216)	\$ (53,873)	\$ (57,089)				
9										
10				Challenger Analysis						
11		P and S								
12	Year	value	AOC	Cash flow						
13	0	\$ (125,000)		\$ (125,000)						
14	1		\$ (31,000)	\$ (31,000)						
15	2		\$ (31,000)	\$ (31,000)						
16	3		\$ (31,000)	\$ (31,000)						
17	4		\$ (31,000)	\$ (31,000)						
18	5	\$ 10,000	\$ (31,000)	\$ (21,000)						
19										
20	AW of C			(66,806)						

11.33 The “opportunity” refers to the ability to receive money by selling the defender. In keeping the defender, the opportunity to receive money is foregone.

11.34 The cash flow approach subtracts the market value of the defender from the first cost of the challenger before amortizing the cost of the challenger.

It is not a good idea to do this approach because:

- (1) It will yield the wrong cost for the challenger if the remaining life of the defender is not *equal* to the life of the challenger, and

- (2) By subtracting the defender market value from the first cost of the challenger, the resulting capital recovery value does not represent the true cost of the challenger (the CR obtained is lower than the true cost). This might result in inaccurate pricing of goods or services provided by the challenger.

11.35 There are four possibilities:

1. Keep the defender for 3 years
2. Use the defender for 2 years and the challenger for 1 year
3. Use the defender for 1 years and the challenger for 2 years
4. Use the challenger for all three years.

The PW cost for each scenario is as follows:

$$\begin{aligned}\text{PW defender for 3 years} &= \$-27,000(P/A, 10\%, 3) \\ &= \$-27,000(2.4869) \\ &= \$-67,146\end{aligned}$$

$$\begin{aligned}\text{PW defender for 2, challenger for 1} &= -24,000(P/A, 10\%, 2) - 29,000(P/F, 10\%, 3) \\ &= -24,000(1.7355) - 29,000(0.7513) \\ &= \$-63,440\end{aligned}$$

$$\begin{aligned}\text{PW defender for 1, challenger for 2} &= -22,000(P/F, 10\%, 1) \\ &\quad - 26,000(P/A, 10\%, 2)(P/F, 10\%, 1) \\ &= -22,000(0.9091) - 26,000(1.7355)(0.9091) \\ &= \$-61,022\end{aligned}$$

$$\begin{aligned}\text{PW challenger for 3 years} &= \$-25,000(P/A, 10\%, 3) \\ &= \$-25,000(2.4869) \\ &= \$-62,173\end{aligned}$$

Lowest PW is \$-61,022 (plan 3); keep the defender for 1 year and then replace it with the challenger

11.36 (a) PW C for 5 years = \$-149,000

$$\begin{aligned}\text{PW D for 1 year, C for 4 years} &= -36,000 - 113,000(P/F, 10\%, 1) \\ &= -36,000 - 113,000(0.9091) \\ &= \$-138,728\end{aligned}$$

$$\begin{aligned}\text{PW D for 2 years, C for 3 years} &= -75,000 - 102,000(P/F, 10\%, 2) \\ &= -75,000 - 102,000(0.8264) \\ &= \$-159,293\end{aligned}$$

$$\begin{aligned}\text{PW D for 3 years, C for 2 years} &= -125,000 - 96,000(P/F, 10\%, 3) \\ &= -125,000 - 96,000(0.7513) \\ &= \$-197,125\end{aligned}$$

$$\begin{aligned}
 \text{PW D for 4 years, C for 1 years} &= -166,000 - 89,000(P/F, 10\%, 4) \\
 &= -166,000 - 89,000(0.6830) \\
 &= \$-226,787
 \end{aligned}$$

$$\text{PW D for 5 years} = \$-217,000$$

Lowest PW is \$-138,728. Therefore, keep the defender 1 year and then replace it with the challenger

- (b) The PW values are placed in the year cell prior to when the year starts for challenger. Lowest PW = \$-138,727 for option E (defender for 1 year, followed by challenger for 4 years)

	A	B	C	D	E	F	G	H	I	J
1										
2		Time in Service, Years		PW of Cash Flows for Each Option, \$ per year						Option
3	Option	Defender	Challenger	0	1	2	3	4	5	PW at 10%, \$
4	A	5	0	-217,000						-217,000
5	B	4	1	-166,000	0	0	0	-89,000		-226,788
6	C	3	2	-125,000	0	0	-96,000			-197,126
7	D	2	3	-75,000	0	-102,000				-159,298
8	E	1	4	-36,000	-113,000					-138,727
9	F	0	5	-149,000						-149,000
10							= NPV(10%,E9:I9) + D9			

11.37 (a) $AW_D = -17,000(A/P, 10\%, 3) - 8000 + 9000(A/F, 10\%, 3)$
 $= -17,000(0.40211) - 8000 + 9000(0.30211)$
 $= \$-12,117$

$$\begin{aligned}
 AW_C &= -40,000(A/P, 10\%, 3) - 3000 + 20,000(A/F, 10\%, 3) \\
 &= -40,000(0.40211) - 3000 + 20,000(0.30211) \\
 &= \$-13,042
 \end{aligned}$$

Keep the defender

(b) $n = 3$ years: $CR = -40,000(A/P, 10\%, 3) + 20,000(A/F, 10\%, 3)$
 $= -40,000(0.40211) + 20,000(0.30211)$
 $= \$-10,042$

$n = 15$ years: $CR = -40,000(A/P, 10\%, 15) + 20,000(A/F, 10\%, 15)$
 $= -40,000(0.13147) + 20,000(0.03147)$
 $= \$-4629$

Required revenue to recover first cost plus 10% per year is reduced over 50% if the full 15-year life is considered rather than the highly shortened 3-year study period.

$$\begin{aligned}
11.38 \quad AW_X &= -82,000(A/P, 15\%, 2) - 30,000 + 42,000(A/F, 15\%, 2) \\
&= -82,000(0.61512) - 30,000 + 42,000(0.46512) \\
&= \$-60,905
\end{aligned}$$

$$\begin{aligned}
AW_Y &= -97,000(A/P, 15\%, 2) - 27,000 + 51,000(A/F, 15\%, 2) \\
&= -97,000(0.61512) - 27,000 + 51,000(0.46512) \\
&= \$-62,946
\end{aligned}$$

Purchase robot X

$$\begin{aligned}
11.39 \text{ (a)} \quad AW_D &= -(70,000 + 40,000)(A/P, 15\%, 3) - 85,000 + 30,000(A/F, 15\%, 3) \\
&= -110,000(0.43798) - 85,000 + 30,000(0.28798) \\
&= \$-124,538
\end{aligned}$$

$$\begin{aligned}
AW_C &= -220,000(A/P, 15\%, 3) - 65,000 + 50,000(A/F, 15\%, 3) \\
&= -220,000(0.43798) - 65,000 + 50,000(0.28798) \\
&= \$-146,957
\end{aligned}$$

Keep the presently-owned machine and replace it in 3 years

$$\begin{aligned}
\text{(b) } n = 3 \text{ years: CR} &= -220,000(A/P, 15\%, 3) + 50,000(A/F, 15\%, 3) \\
&= -220,000(0.43798) + 50,000(0.28798) \\
&= \$-81,957
\end{aligned}$$

$$\begin{aligned}
n = 8 \text{ years: CR} &= -220,000(A/P, 15\%, 8) + 10,000(A/F, 15\%, 8) \\
&= -220,000(0.22285) + 10,000(0.07285) \\
&= \$-48,299
\end{aligned}$$

Required revenue to recover first cost plus 15% per year is reduced over 40% if the full 8-year life is considered rather than the abbreviated 3-year study period.

11.40 (a) For 2-year study period

$$\begin{aligned}
AW_K &= -165,000(A/P, 12\%, 2) - 69,000 + 40,000(A/F, 12\%, 2) \\
&= -165,000(0.59170) - 69,000 + 40,000(0.47170) \\
&= \$-147,763
\end{aligned}$$

$$\begin{aligned}
AW_L &= -230,000(A/P, 12\%, 2) - 65,000 + 70,000(A/F, 12\%, 2) \\
&= -230,000(0.59170) - 65,000 + 70,000(0.47170) \\
&= \$-168,072
\end{aligned}$$

Process K is selected

(b) For 3-year study period, must re-purchase K for only 1 year.

$$\begin{aligned} AW_K &= -165,000(A/P, 12\%, 3) - 69,000 \\ &\quad + (-165,000 + 40,000)(P/F, 12\%, 2)(A/P, 12\%, 3) + 50,000(A/F, 12\%, 3) \\ &= -165,000(0.41635) - 69,000 - 125,000(0.7972)(0.41635) \\ &\quad + 50,000(0.29635) \\ &= \$-164,370 \end{aligned}$$

$$\begin{aligned} AW_L &= -230,000(A/P, 12\%, 3) - 65,000 + 45,000(A/F, 12\%, 3) \\ &= -230,000(0.41635) - 65,000 + 45,000(0.29635) \\ &= \$-147,425 \end{aligned}$$

Now, process L is selected

11.41 In \$ million units, use the market value estimates in Example 11.3 (Figure 11-3) to calculate CR for $n = 6$ and $n = 12$ years for the challenger GH.

PE

$$\begin{aligned} n = 6 \text{ years: CR} &= -38(A/P, 15\%, 6) + 5.93(A/F, 15\%, 6) \\ &= -38(0.26424) + 5.93(0.11424) \\ &= \$-9.36 \quad (\$-9.36 \text{ million}) \end{aligned}$$

$$\begin{aligned} n = 12 \text{ years: CR} &= -38(A/P, 15\%, 12) + 1.06(A/F, 15\%, 12) \\ &= -38(0.18448) + 1.06(0.03448) \\ &= \$-6.97 \quad (\$-6.97 \text{ million}) \end{aligned}$$

Required revenue to recover \$38 million first cost plus 15% per year is reduced over 25% if the full 12-year life is considered rather than the abbreviated 6-year study period.

11.42 (a) There are 6 options. Spreadsheet screen shot shows the AW of the current system (defender D) for its retention period with close-down cost in last year, followed by annual contract cost (challenger C) for years in effect. The most economic is:

Select option 5; retain current system for 4 years; purchase contract for the 5th year only at \$5,500,000, assuming the contract cost remains as quoted now. Estimated AW = \$-3.61 million per year.

	A	B	C	D	E	F	G	H	I	J	K	L
1	i = 8%					values are in						(b)
2	Cash flow for different study period lengths, \$ per year											% change
3	Option	D	C	0	1	2	3	4	5	PW	AW	in AW
4	1	0	5	-3,000	-5,000	-5,000	-5,000	-5,000	-5,000	(\$22,964)	(\$5,751)	-
5	2	1	4	-	-4,800	-5,000	-5,000	-5,000	-5,000	(\$19,778)	(\$4,954)	-13.9%
6	3	2	3	-	-2,300	-4,300	-5500	-5500	-5500	(\$17,968)	(\$4,500)	-9.2%
7	4	3	2	-	-3,000	-3,000	-4,000	-5500	-5500	(\$16,311)	(\$4,085)	-9.2%
8	5	4	1	-	-3,000	-3,000	-3,000	-4,000	-5500	(\$14,415)	(\$3,610)	-11.6%
9	6	5	0	-	-3,700	-3,700	-3,700	-3,700	-4,200	(\$15,113)	(\$3,785)	4.8%
10												
11					Includes close-down expense			=-3700-500		=PMT(\$B\$1,5,J9)		
12												

(b) Percentage change (column L) is negative for increasing years of defender retention until 5 years, where percentage turns positive (cell L9).

If option 6 is selected over the better option 5, the economic disadvantage is $3,785,000 - 3,610,000 = \$175,000$ equivalent per year for the 5 years.

$$11.43 \quad -RV(A/P, 12\%, 3) - 27,000 + 30,000(A/F, 12\%, 3) = -400,000(A/P, 12\%, 5) - 50,000 + 45,000(A/F, 12\%, 5)$$

$$-RV(0.41635) - 27,000 + 30,000(0.29635) = -400,000(0.27741) - 50,000 + 45,000(0.15741)$$

$$0.41635 \text{ RV} = 135,771 \\ \text{RV} = \$326,098$$

$$11.44 \quad -RV(A/P, 12\%, 3) - 63,000 + 25,000(A/F, 12\%, 3) = -130,000(A/P, 12\%, 6) - 32,000 + 45,000(A/F, 12\%, 6)$$

$$-RV(0.41635) - 63,000 + 25,000(0.29635) = -130,000(0.24323) - 32,000 + 45,000(0.12323)$$

$$0.41635 \text{ RV} = 2483 \\ \text{RV} = \$5964$$

$$11.45 \quad -RV(A/P, 10\%, 2) - 75,000 = -220,000(A/P, 10\%, 6) - 49,000 + 30,000(A/F, 10\%, 6)$$

$$-RV(0.57619) - 75,000 = -220,000(0.22961) - 49,000 + 30,000(0.12961)$$

$$0.57619 \text{ RV} = 20,626 \\ \text{RV} = \$35,797$$

$$11.46 \quad -RV(A/P, 12\%, 3) - [140,000 + 2000(A/G, 12\%, 3)] = -150,000(A/P, 12\%, 8) \\ - [82,000 + 500(A/G, 12\%, 8)] + 50,000(A/F, 12\%, 8)$$

$$-RV(0.41635) - [140,000 + 2000(0.9246)] = -150,000(0.20130) \\ - [82,000 + 500(2.9131)] + 50,000(0.08130)$$

$$0.41635 \quad RV = 32,263 \\ RV = \$77,489$$

11.47 Answer is (b)

11.48 Answer is (d)

11.49 Answer is (d)

11.50 Lowest annual worth occurs if the asset is kept for 2 years

Answer is (b)

11.51 For a 3-year period, $AW_D = \$-70,000$ and $AW_C = \$-75,000$. Do not replace.

Four options are present, but they have the same conclusion.

Years kept		AW per year, \$1000			AW over 3 years, \$1000
Defender	Challenger	1	2	3	
3	0	-70	-70	-70	-70.0
2	1	-70	-70	-80	-72.9
1	2	-70	-80	-80	-76.2
0	3	-80	-80	-80	-80.0

Answer is (d)

11.52 For any time during the next 3, 4 or 5 years, the lowest AW of \$-65,000 per year will occur by replacing the existing machine now.

Answer is (a)

11.53 Answer is (b)

11.54 The company should *never* purchase the challenger, because its AW of \$-86,000 is higher than the defender's 2-year ESL of \$-81,000. The defender should be kept for 2 more years and then replaced with another used machine just like the one presently owned.

Answer is (d)

11.55 Defender: ESL is 2 years with $AW = \$-13,700$
Challenger: ESL is 3 years with $AW = \$-13,100$

Replace now.

Answer is (a)

Solution to Case Study, Chapter 11

Sometimes, there is not a definitive answer to a case study exercise. Here are example responses.

WILL THE CORRECT ESL PLEASE STAND?

1. The ESL is 13 years. Year 13 is predicted to require the 4th rebuild; the pump will not be used beyond 13 years anyway.

	A	B	C	D	E	F	G	H	I	J	K
1	#1. Find the ESL										
2									Operating	Cumulative	
3								Year	hours	hours	
4		First cost &		Capital	AW of AOC	Total		1	500	500	
5	Year	rebuild cost	AOC	recovery	and rebuild	AW		2	1500	2000	
6	0	\$ (800,000)						3	2000	4000	
7	1	\$ -	\$ (25,000)	\$ (880,000)	\$ (25,000)	\$ (905,000)		4	2000	6000	Rebuild
8	2	\$ -	\$ (25,000)	\$ (460,952)	\$ (25,000)	\$ (485,952)		5	2000	8000	
9	3	\$ -	\$ (25,000)	\$ (321,692)	\$ (25,000)	\$ (346,692)		6	2000	10000	
10	4	\$ (150,000)	\$ (25,000)	\$ (252,377)	\$ (57,321)	\$ (309,697)		7	2000	12000	Rebuild
11	5	\$ -	\$ (40,000)	\$ (211,038)	\$ (54,484)	\$ (265,522)		8	2000	14000	
12	6	\$ -	\$ (46,000)	\$ (183,686)	\$ (53,384)	\$ (237,070)		9	2000	16000	
13	7	\$ (180,000)	\$ (52,900)	\$ (164,324)	\$ (72,306)	\$ (236,630)		10	2000	18000	Rebuild
14	8	\$ -	\$ (60,835)	\$ (149,955)	\$ (71,303)	\$ (221,258)		11	2000	20000	
15	9	\$ -	\$ (69,960)	\$ (138,912)	\$ (71,204)	\$ (210,116)		12	2000	22000	
16	10	\$ (216,000)	\$ (80,454)	\$ (130,196)	\$ (85,337)	\$ (215,534)		13	2000	24000	Replace
17	11	\$ -	\$ (92,522)	\$ (123,171)	\$ (85,725)	\$ (208,896)					
18	12	\$ -	\$ (106,401)	\$ (117,411)	\$ (86,692)	\$ (204,103)					
19	13	\$ -	\$ (122,361)	\$ (112,623)	\$ (88,147)	\$ (200,769)	ESL				
20											
21	Answer: ESL is 13 years with AW = \$-200,769										

2. Required MV = \$1,420,983 found using Solver with F12 the target cell and B12 the changing cell. This MV is well above the first cost of \$800,000.

	A	B	C	D	E	F	G	H	I	J	K	L
1	#2. Find required market value at end of year 6 to make ESL be n = 6 years											
2									Operating	Cumulative		
3								Year	hours	hours		
4		First cost &		Capital	AW of AOC	Total		1	500	500		
5	Year	rebuild cost	AOC	recovery	and rebuild	AW		2	1500	2000		
6	0	\$ (800,000)						3	2000	4000		
7	1	\$ -	\$ (25,000)	\$ (880,000)	\$ (25,000)	\$ (905,000)		4	2000	6000	Rebuild	
8	2	\$ -	\$ (25,000)	\$ (460,952)	\$ (25,000)	\$ (485,952)		5	2000	8000		
9	3	\$ -	\$ (25,000)	\$ (321,692)	\$ (25,000)	\$ (346,692)		6	2000	10000		
10	4	\$ (150,000)	\$ (25,000)	\$ (252,377)	\$ (57,321)	\$ (309,697)		7	2000	12000	Rebuild	
11	5	\$ -	\$ (40,000)	\$ (211,038)	\$ (54,484)	\$ (265,522)		8	2000	14000		
12	6	\$ 1,420,983	\$ (46,000)	\$ (183,686)	\$ 130,786	\$ (52,900)	ESL	9	2000	16000		
13	7	\$ -	\$ (52,900)	\$ (164,324)	\$ 111,424	\$ (52,900)		10	2000	18000	Rebuild	
14	8	\$ -	\$ (60,835)	\$ (149,955)	\$ 96,361	\$ (53,594)		11	2000	20000		
15	9	\$ -	\$ (69,960)	\$ (138,912)	\$ 84,113	\$ (54,799)		12	2000	22000		
16	10	\$ -	\$ (80,454)	\$ (130,196)	\$ 73,787	\$ (56,409)		13	2000	24000	Replace	
17	11	\$ -	\$ (92,522)	\$ (123,171)	\$ 64,813	\$ (58,358)						
18	12	\$ -	\$ (106,401)	\$ (117,411)	\$ 56,806	\$ (60,604)						
19	13	\$ -	\$ (122,361)	\$ (112,623)	\$ 49,500	\$ (63,123)						
20												
21	Answer: The market value would be extremely high at \$1.42 million to make ESL be 6 years.											
22	This is substantially more than the pump cost new at \$800,000.											

3. Solver yields the base AOC = \$-201,983 in year 1 with increases of 15% per year. The rebuild cost in year 4 (after 6000 hours) is \$150,000. This AOC series is huge compared to the estimated AOC of \$25,000 (years 1 – 4).

	A	B	C	D	E	F	G	H	I	J	K
1	#3. Find the base AOC to make ESL be n = 6 years; no rebuild done										
2									Operating	Cumulative	
3		AOC, \$/year	-\$201,982.83					Year	hours	hours	
4		First cost &		Capital	AW of AOC	Total		1	500	500	
5	Year	rebuild cost	AOC	recovery	and rebuild	AW		2	1500	2000	
6	0	\$ (800,000)						3	2000	4000	
7	1	\$ -	\$ (201,983)	\$ (880,000)	\$ (201,983)	\$ (1,081,983)		4	2000	6000	
8	2	\$ -	\$ (232,280)	\$ (460,952)	\$ (216,410)	\$ (677,363)		5	2000	8000	
9	3	\$ -	\$ (267,122)	\$ (321,692)	\$ (496,520)	\$ (818,212)		6	2000	10000	Sell
10	4	\$ -	\$ (307,191)	\$ (252,377)	\$ (247,990)	\$ (500,367)					
11	5	\$ -	\$ (353,269)	\$ (211,038)	\$ (265,235)	\$ (476,273)					
12	6	\$ -	\$ (406,260)	\$ (183,686)	\$ (283,513)	\$ (467,199)	ESL				
13	7		\$ (467,199)	\$ (164,324)	\$ (302,874)	\$ (467,199)					
14											
15	Answer: This is also not very reasonable. The AOC base in year 1 would have to be very large										
16			at \$201,982 per year to force ESL to be 6 years.								

4. Compare the results in #2 and #3 with that in #1 and comment on them.

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 12
Independent Projects With Budget Limitation

12.1 *Bundle*: a collection of independent projects

Contingent project: has a condition placed on its acceptance or rejection

Dependent project: accepted or rejected based on the decision about another project(s)

12.2 Two assumptions are:

- (1) The funds invested in every project will remain invested for the period of the longest lived project, and
- (2) Reinvestment of any positive net cash flows is assumed to be at the MARR from the time they are realized until the end of the longest-lived project.

12.3 Number of bundles = $2^7 = 128$

12.4 There are a total of $2^4 = 16$ possible bundles. No bundle with X and Y are listed; 12 remain.

W, X, Y, Z, WX, WY, WZ, XZ, YZ, WXZ, WYZ, and DN

12.5 (a) There are a total of $2^5 = 32$ possible bundles; only 5 are within a budget constraint of \$34,000.

Bundle	Total PW of Investment, \$
P	6,000
M	11,000
L	28,000
PM	17,000
PL	34,000

(b) Only 10 bundles are within the budget constraint of \$45,000.

Bundle	Total PW of Investment, \$	Bundle	Total PW of Investment, \$
P	6,000	PM	17,000
M	11,000	PL	34,000
L	28,000	PO	44,000
O	38,000	ML	39,000
N	43,000	LMP	45,000

- 12.6** There are $2^4 = 16$ possible bundles. Considering the selection restrictions, the 9 viable bundles are:

DN	4	34
1	13	123
3	23	234

Not acceptable bundles: 2, 12, 14, 24, 124, 134, 1234

- 12.7** There are $2^4 = 16$ possible bundles. Considering the selection restriction and the \$400 limitation, the viable bundles are:

<u>Projects</u>	<u>Investment</u>
DN	\$ 0
2	150
3	75
4	235
2, 3	225
2, 4	385
3, 4	310

- 12.8** Select the bundle with the highest positive PW value that do not violate the budget limit of \$45,000. Select bundle 4.

- 12.9** (a) Select projects 2, 3 and 4 with $PW > 0$ at 18%.

- (b) Of $2^4 = 16$ bundles, list acceptable bundles and PW values. Select project 4 with highest PW of \$9600.

Bundle	Investment	PW
DN	0	0
2	\$-25,000	\$ 8,500
3	-20,000	500
4	-40,000	9,600
2,3	-45,000	9,000

- 12.10** Sample calculations: $PW_I = -25,000 + 6000(P/A, 15\%, 4) + 4000(P/F, 15\%, 4)$
 $= -25,000 + 6000(2.8550) + 4000(0.5718)$
 $= \$-5583$

$$\begin{aligned}
 PW_{I,II} &= -55,000 + 15,000(P/A, 15\%, 4) + 3000(P/F, 15\%, 4) \\
 &= -55,000 + 15,000(2.8550) + 3000(0.5718) \\
 &= \$-10,460
 \end{aligned}$$

(Note: Can use NPV spreadsheet function to get PW values.)

Bundle	Proposals	PW at 15%, \$
1	I	-5583
2	II	-4877
3	III	4261
4	I,II	-10,460
5	I,III	-1322
6	II,III	-616

Select bundle 3, since it has largest, and only, $PW > 0$

12.11 (a) *Hand solution:*

$$\begin{aligned}
 \text{Sample calculation: } PW_{A,B} &= -45,000 + 15,000(P/A, 15\%, 4) \\
 &\quad + 4000(P/F, 15\%, 4) \\
 &= -45,000 + 15,000(2.8550) + 4000(0.5718) \\
 &= \$112
 \end{aligned}$$

Bundle	Proposals	PW at 15%, \$
1	A	-5583
2	B	+5695
3	C	+4261
4	A,B	+112
5	A,C	-1322
6	B,C	+9956
7	A,B,C	+4371
8	Do nothing	0

Select bundle 6 (proposals B & C), since it has largest PW at \$9956

(b) *Spreadsheet solution:* Same result; select B and C.

	A	B	C	D	E	F	G	H	I
1	MARR =	15%							
2									
3	Bundle	1	2	3	4	5	6	7	8
4	Projects	A	B	C	AB	AC	BC	ABC	Do nothing
5	Year								
6	0	-25,000	-20,000	-50,000	-45,000	-75,000	-70,000	-95,000	0
7	1	6,000	9,000	15,000	15,000	21,000	24,000	30,000	0
8	2	6,000	9,000	15,000	15,000	21,000	24,000	30,000	0
9	3	6,000	9,000	15,000	15,000	21,000	24,000	30,000	0
10	4	10,000	9,000	35,000	19,000	45,000	44,000	54,000	0
11									
12									
13									
14									
15									
16	PW @ 15%	-5,583	5,695	4,260	112	-1,323	9,955	4,371	0

= NPV(\$B\$1,G7:G10) + G6

12.12 Determine the PW for each project.

$$PW_A = -1,500,000 + 360,000(P/A, 10\%, 8) = \$420,564$$

$$PW_B = -3,000,000 + 600,000(P/A, 10\%, 10) = \$686,760$$

$$PW_C = -1,800,000 + 620,000(P/A, 10\%, 5) = \$550,296$$

$$PW_D = -2,000,000 + 630,000(P/A, 10\%, 4) = \$-2,963 \text{ (not acceptable)}$$

By spreadsheet, enter the following to display the project PW values.

$$A: = -PV(10\%, 8, 360000) - 1500000 \quad \text{Display: } \$420,573$$

$$B: = -PV(10\%, 10, 600000) - 3000000 \quad \text{Display: } \$686,740$$

$$C: = -PV(10\%, 5, 620000) - 1800000 \quad \text{Display: } \$550,288$$

$$D: = -PV(10\%, 4, 630000) - 2000000 \quad \text{Display: } \$-2,985$$

Formulate acceptable bundles from the $2^4 = 16$ possibilities, without both B and C and select projects with largest total PW of a bundle.

(a) With $b = \$4$ million, select projects A and C with $PW = \$970,860$.

Bundle	Investment	PW, \$
	\$ Million	
DN	0	0
A	-1.5	420,564
B	-3.0	686,760
C	-1.8	550,296
A,C	-3.3	970,860

(b) With $b = \$5.5$ million, select projects A and B with $PW = \$1,107,313$.

Bundle	Investment	PW, \$
	\$ Million	
DN	0	0
A	-1.5	420,564
B	-3.0	686,760
C	-1.8	550,296
A,B	-4.5	1,107,313
A,C	-3.3	970,860

(c) With no-limit, select all with $PW > 0$. Select projects A, B and C.

12.13 Hand calculate each project's PW using P/F factors since all NCF are different each year. Alternatively, use a spreadsheet.

	A	B	C	D	E
1		NCF, \$ per year			
2	Year	W	X	Y	Z
3	0	-5000	-8000	-8000	-10,000
4	1	1000	900	4000	0
5	2	1700	950	3000	0
6	3	1800	1000	1000	0
7	4	2500	1050	500	17,000
8	5	2000	10,500	500	
9	6			2000	
10	PW at 8%	\$ 2,011	\$ 2,360	\$ 1,038	\$ 2,496

Use $b = \$20,000$ to formulate bundles from the $2^4 = 16$ possibilities. Select projects X and Z with $PW = \$4,856$.

Bundle	Investment, \$	PW, \$
DN	0	0
W	-5,000	2,011
X	-8,000	2,360
Y	-8,000	1,038
Z	-10,000	2,496
WX	-13,000	4,371
WY	-13,000	3,049
WZ	-15,000	4,507
XY	-16,000	3,398
XZ	-18,000	4,856
YZ	-18,000	3,534

12.14 Determine PW values at 0.5% per month by spreadsheet using the PV function = -PV(0.5%,36,revenue) - cost, or by hand, as follows.

$$PW_{\text{diag}} = -45,000 + 2200(P/A, 0.5\%, 36) = \$27,316$$

$$PW_{\text{exh}} = -30,000 + 2000(P/A, 0.5\%, 36) = \$35,742$$

$$PW_{\text{hybrid}} = -22,000 + 1500(P/A, 0.5\%, 36) = \$27,307$$

With $2^3 = 8$ bundles and $b = \$70,000$, select the last two features with $PW = \$63,049$.

Bundle	Investment, \$	PW, \$
DN	0	0
Diagnostics	-45,000	27,316
Exhaust	-30,000	35,742
Hybrid	-22,000	27,307
Diag/hybrid	-67,000	54,623
Exh/hybrid	-52,000	63,049

- 12.15** (a) Develop the bundles with up to \$315,000 investment, and select the one with the largest PW value.

Bundle	Projects	Initial investment, \$	NCF, \$ per year	PW at 10%, \$
1	A	-100,000	50,000	166,746
2	B	-125,000	24,000	3,038
3	C	-120,000	75,000	280,118
4	D	-220,000	39,000	-11,939
5	E	-200,000	82,000	237,462
6	AB	-225,000	74,000	169,784
7	AC	-220,000	125,000	446,864
8	AE	-300,000	132,000	404,208
9	BC	-245,000	99,000	283,156
10	DN	0	0	0

$$\begin{aligned}
 PW_A &= -100,000 + 50,000(P/A, 10\%, 8) \\
 &= -100,000 + 50,000(5.3349) \\
 &= \$166,746
 \end{aligned}$$

$$\begin{aligned}
 PW_B &= -125,000 + 24,000(P/A, 10\%, 8) \\
 &= -125,000 + 24,000(5.3349) \\
 &= \$3,038
 \end{aligned}$$

$$\begin{aligned}
 PW_C &= -120,000 + 75,000(P/A, 10\%, 8) \\
 &= -120,000 + 75,000(5.3349) \\
 &= \$280,118
 \end{aligned}$$

$$\begin{aligned}
 PW_D &= -220,000 + 39,000(P/A, 10\%, 8) \\
 &= -220,000 + 39,000(5.3349) \\
 &= \$-11,939
 \end{aligned}$$

$$\begin{aligned}
 PW_E &= -200,000 + 82,000(P/A, 10\%, 8) \\
 &= -200,000 + 82,000(5.3349) \\
 &= \$237,462
 \end{aligned}$$

All other PW values are obtained by adding the respective PW for bundles 1 through 5.

Conclusion: Select PW = \$446,864, which is bundle 7 (projects A and C) with \$220,000 total investment.

- (b) For mutually exclusive alternatives, select the single project with the largest PW. This is C, with PW = \$280,118.

12.16 (a) For $b = \$30,000$ only 5 bundles are viable of the 32 possibilities.

Bundle	Projects	Initial investment, \$	PW at 12%, \$
1	S	-15,000	8,540
2	A	-25,000	12,325
3	M	-10,000	3,000
4	E	-25,000	10
5	SM	-25,000	11,540

Select project A with $PW = \$12,325$ and $\$25,000$ invested.

(b) With $b = \$52,000$, 9 more bundles are viable.

Bundle	Projects	Initial investment, \$	PW at 12%, \$
6	H	-40,000	15,350
7	SA	-40,000	20,865
8	SE	-40,000	8,550
9	AM	-35,000	15,325
10	AE	-50,000	12,335
11	ME	-35,000	3,010
12	MH	-50,000	18,350
13	SAM	-50,000	23,865
14	SME	-50,000	11,550

Select projects S, A and M with $PW = \$23,865$ and $\$50,000$ invested.

(c) Select all projects since they each have $PW > 0$ at 12%.

12.17 (a) *Hand:* The bundles and PW values are determined at $MARR = 8\%$ per year.

Bundle	Projects	Initial Investment, \$M	NCF, \$ per year	Life, years	PW at 8%, \$
1	1	-1.5	360,000	8	568,776
2	2	-3.0	600,000	10	1,026,060
3	3	-1.8	520,000	5	276,204
4	4	-2.0	820,000	4	715,922
5	1,3	-3.3	880,000	1-5	844,980
			360,000	6-8	
6	1,4	-3.5	1,180,000	1-4	1,284,698
			360,000	5-8	
7	3,4	-3.8	1,340,000	1-4	992,126
			520,000	5	

Select $PW = \$1.285$ million for projects 1 and 4 with $\$3.5$ million invested.

(b) *Spreadsheet*: Set up a spreadsheet for all 7 bundles. Select projects 1 and 4 with the largest PW = \$1,284,730 and invest \$3.5 million.

	A	B	C	D	E	F	G	H
1	MARR =	8%						
2								
3	Bundle	1	2	3	4	5	6	7
4	Projects	1	2	3	4	1,3	1,4	3,4
5	Year	Net cash flows (NCF), \$1000 per year						
6	0	-1,500	-3,000	-1,800	-2,000	-3,300	-3,500	-3,800
7	1	360	600	520	820	880	1,180	1,340
8	2	360	600	520	820	880	1,180	1,340
9	3	360	600	520	820	880	1,180	1,340
10	4	360	600	520	820	880	1,180	1,340
11	5	360	600	520		880	360	520
12	6	360	600			360	360	
13	7	360	600			360	360	
14	8	360	600			360	360	
15	9		600					
16	10		600					
17	PW Value	\$568.79	\$1,026	\$276.21	\$715.94	\$845.00	\$1,284.73	\$992.15
18								
19								
20		= NPV(\$B\$1,B7:B16)+B6						
21								

12.18 Budget limit $b = \$16,000$

MARR = 12% per year

Bundle	Projects	Investment	NCF for years 1-5, \$	PW at 12%, \$
1	1	\$-5,000	1000,1700,2400, 3000,3800	3019
2	2	- 8,000	500,500,500, 500,10500	-523
3	3	- 9,000	5000,5000,2000	874
4	4	-10,000	0,0,0,17000	804
5	1,2	-13,000	1500,2200,2900, 3500, 14300	2496
6	1,3	-14,000	6000,6700,4400, 3000,3800	3893
7	1,4	-15,000	1000,1700,2400, 20000,3800	3823
8	DN	0	0	0

Since $PW_6 = \$3893$ is largest, select bundle 6, which is projects 1 and 3.

12.19 Spreadsheet solution for Problem 12.18. Projects 1 and 3 are selected with PW = \$3893

	A	B	C	D	E	F	G	H	I
1	MARR =	12.0%							
2									
3	Bundle	1	2	3	4	4	5	6	7
4	Projects	1	2	3	4	1,2	1,3	1,4	DN
5	Year	Net cash flows, NCF, \$ per year							
6	0	-5,000	-8,000	-9,000	-10,000	-13,000	-14,000	-15,000	0
7	1	1,000	500	5,000	0	1,500	6,000	1,000	0
8	2	1,700	500	5,000	0	2,200	6,700	1,700	0
9	3	2,400	500	2,000	0	2,900	4,400	2,400	0
10	4	3,000	500		17,000	3,500	3,000	20,000	0
11	5	3,800	10,500			14,300	3,800	3,800	0
12	PW Value	3,019	-523	874	804	2,496	3,893	3,823	0

12.20 (a) Spreadsheet shows the solution. Select projects 1 and 2 for an investment of \$3.0 million and PW = \$753,139.

	A	B	C	D	E	F	G
1	MARR =	12.5%					
2							
3	Bundle	1	2	3	4	4	5
4	Projects	1	2	3	1,2	1,3	DN
5	Year	Net cash flows, NCF, \$					
6	0	-900,000	-2,100,000	-1,000,000	-3,000,000	-1,900,000	0
7	1	250,000	485,000	200,000	735,000	450,000	0
8	2	245,000	490,000	240,000	735,000	485,000	0
9	3	240,000	495,000	288,000	735,000	528,000	0
10	4	235,000	500,000	345,600	735,000	580,600	0
11	5	230,000	505,000	414,720	735,000	644,720	0
12	6	225,000	510,000		735,000	225,000	0
13	7	0	515,000		515,000		0
14	8	0	520,000		520,000		0
15	9	0	525,000		525,000		0
16	10	0	530,000		530,000		0
17	PW Value	69,691	683,448	15,576	753,139	85,266	0

- (b) The Goal Seek target cell is D17 to equal \$753,139. Result is a reduced year-one NCF for project 3 of \$145,012. However, with these changes for project 3, the best selection is now projects 1 and 3 with PW = \$822,830.

	A	B	C	D	E	F	G
1	MARR =	12.5%		Reduced NCF after Goal Seek solution			
2							
3	Bundle	1	2	3	4	4	5
4	Projects	1	2	3	1,2	1,3	DN
5	Year	Net cash flows, NCF, \$ per year					
6	0	-900,000	-2,100,000	-1,000,000	-3,000,000	-1,900,000	0
7	1	250,000	485,000	145,012	735,000	395,012	0
8	2	245,000	490,000	174,014	735,000	419,014	0
9	3	240,000	495,000	208,817	735,000	448,817	0
10	4	235,000	500,000	250,581	735,000	485,581	0
11	5	230,000	505,000	300,697	735,000	530,697	0
12	6	225,000	510,000	360,836	735,000	585,836	0
13	7		515,000	433,003	515,000	433,003	0
14	8		520,000	519,604	520,000	519,604	0
15	9		525,000	623,525	525,000	623,525	0
16	10		530,000	748,230	530,000	748,230	0
17	PW Value	69,691	683,448	753,139	753,139	822,830	0

12.21 To develop the 0-1 ILP formulation, first calculate PW_E , since it was not included in Table 12-2. All amounts are in \$1000.

$$\begin{aligned}
 PW_E &= -21,000 + 9500(P/A, 15\%, 9) \\
 &= -21,000 + 9500(4.7716) \\
 &= \$24,330
 \end{aligned}$$

The linear programming formulation is:

$$\text{Maximize } Z = 3694x_1 - 1019x_2 + 4788x_3 + 6120x_4 + 24,330x_5$$

$$\text{Constraints: } 10,000x_1 + 15,000x_2 + 8000x_3 + 6000x_4 + 21,000x_5 < 20,000$$

$$x_k = 0 \text{ or } 1 \text{ for } k = 1 \text{ to } 5$$

- (a) For $b = \$20,000$: The spreadsheet solution uses the template in Figure 12-5. MARR is set to 15% and a budget constraint is set to \$20,000 in Solver. Projects C and D are selected (row 19) for a \$14,000 investment with $Z = \$10,908$ (cell I2), as in Example 12.1.

	A	B	C	D	E	F	G	H	I
1	MARR = 15%								
2								Maximum Z =	\$ 10,908
3									
4	Projects	A	B	C	D	E			
5	Year	Net cash flows, NCF, \$ per year							
6	0	-10,000	-15,000	-8,000	-6,000	-21,000			
7	1	2,870	2,930	2,680	2,540	9,500			
8	2	2,870	2,930	2,680	2,540	9,500			
9	3	2,870	2,930	2,680	2,540	9,500			
10	4	2,870	2,930	2,680	2,540	9,500			
11	5	2,870	2,930	2,680	2,540	9,500			
12	6	2,870	2,930	2,680	2,540	9,500			
13	7	2,870	2,930	2,680	2,540	9,500			
14	8	2,870	2,930	2,680	2,540	9,500			
15	9	2,870	2,930	2,680	2,540	9,500			
16	10								
17	11								
18	12								
19	Projects selected	0	0	1	1	0			
20	PW value at MARR, \$	3,694	-1,019	4,788	6,120	24,330			
21	Contribution to Z, \$	0	0	4,788	6,120	0			
22	Investment, \$	0	0	8,000	6,000	0		Total =	\$ 14,000

Solver Parameters
Set Target Cell:
Equal To: ☒ Max ☐ Min ☐ Value of:
By Changing Cells:
Subject to the Constraints:

(b) $b = \$13,000$: Reset the budget constraint to $b = \$13,000$ in Solver and obtain a new solution to select only project D with $Z = \$6120$ and only \$6000 of the \$13,000 invested.

12.22 Use the capital budgeting problem template at 8% with an investment limit of \$4 million. Select projects 1 and 4 with \$3.5 million invested and $Z \approx \$1.285$ million.

	A	B	C	D	E	F	G	H	I
1	MARR =	8%							
2									
3									
4	Projects	1	2	3	4	5	6		
5	Year	Net cash flows, NCF, \$						Maximum Z =	\$ 1,284,734
6	0	-1,500,000	-3,000,000	-1,800,000	-2,000,000				
7	1	360,000	600,000	520,000	820,000				
8	2	360,000	600,000	520,000	820,000				
9	3	360,000	600,000	520,000	820,000				
10	4	360,000	600,000	520,000	820,000				
11	5	360,000	600,000	520,000					
12	6	360,000	600,000						
13	7	360,000	600,000						
14	8	360,000	600,000						
15	9		600,000						
16	10		600,000						
17	11								
18	12								
19	Projects selected	1	0	0	1	0	0		
20	PW value at MARR,	568,790	1,026,049	276,209	715,944	0	0		
21	Contribution to Z, \$	568,790	0	0	715,944	0	0		
22	Investment, \$	1,500,000	0	0	2,000,000	0	0	Total =	\$ 3,500,000

12.23 Enter the NCF values from Problem 12.20 into the capital budgeting template and $b = \$3,000,000$ into Solver. Select projects 1 and 2 for $Z = \$753,139$ with \$3.0 million invested.

	A	B	C	D	E	F	G	H	I
1	MARR =	12.5%							
2									
3									
4	Projects	1	2	3	4	5	6		
5	Year	Net cash flows, NCF, \$ per year						Maximum Z =	\$ 753,139
6	0	-900,000	-2,100,000	-1,000,000					
7	1	250,000	485,000	200,000					
8	2	245,000	490,000	240,000					
9	3	240,000	495,000	288,000					
10	4	235,000	500,000	345,600					
11	5	230,000	505,000	414,720					
12	6	225,000	510,000						
13	7		515,000						
14	8		520,000						
15	9		525,000						
16	10		530,000						
17	11								
18	12								
19	Projects selected	1	1	0	0	0	0		
20	PW value at MARR, \$	69,691	683,448	15,576	0	0	0		
21	Contribution to Z, \$	69,691	683,448	0	0	0	0		
22	Investment, \$	900,000	2,100,000	0	0	0	0	Total =	\$ 3,000,000

12.24 *Linear programming model:* In \$1000 units,

$$\text{Maximize } Z = 3019x_1 - 523x_2 + 874x_3 + 804x_4$$

$$\text{Constraints: } 5,000x_1 + 8,000x_2 + 9000x_3 + 10000x_4 < 16,000$$

$$x_k = 0 \text{ or } 1 \text{ for } k = 1 \text{ to } 4$$


Spreadsheet solution: Enter the NCF values on a spreadsheet and $b = \$16,000$ constraint in Solver to obtain the answer:

Select projects 1 and 3 with $Z = \$3893$ and \$14 million invested


This is the same as in Problem 12.18 where all viable mutually exclusive bundles were evaluated by hand.

	A	B	C	D	E	F	G	H	I
1	MARR =	12.0%							
2									
3									
4	Projects	1	2	3	4	5	6		
5	Year	Net cash flows, NCF, \$ per year						Maximum Z =	\$ 3,893
6	0	-5,000	-8,000	-9,000	-10,000				
7	1	1,000	500	5,000	0				
8	2	1,700	500	5,000	0				
9	3	2,400	500	2,000	0				
10	4	3,000	500		17,000				
11	5	3,800	10,500						
12	6								
13	7								
14	8								
15	9								
16	10								
17	11								
18	12								
19	Projects selected	1	0	1	0	0	0		
20	PW value at MARR, \$	3,019	-523	874	804	0	0		
21	Contribution to Z, \$	3,019	0	874	0	0	0		
22	Investment, \$	5,000	0	9,000	0	0	0	Total =	\$ 14,000


Solver Parameters


Set Target Cell: 

Equal To: ☒ Max ☐ Min ☐ Value of:

By Changing Cells: 

Subject to the Constraints:





12.25 Build a spreadsheet and use Solver repeatedly at increasing values of b to find the projects that maximize the value of Z. Develop a scatter chart.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	MARR = 12%												
2													
3													
4	Projects	1	2	3	4	5	6				Capital	Value	Project(s)
5	Year	Net cash flows, NCF						Maximum Z =	\$ 4,697		Budget, \$	of Z, \$	Selected
6	0	\$(5,000)	\$(8,000)	\$(9,000)	\$(10,000)						\$ 5,000	3019	1
7	1	\$ 1,000	\$ 500	\$ 5,000	\$ -						\$ 6,000	3019	1
8	2	\$ 1,700	\$ 500	\$ 5,000	\$ -						\$ 7,000	3019	1
9	3	\$ 2,400	\$ 500	\$ 2,000	\$ -						\$ 8,000	3019	1
10	4	\$ 3,000	\$ 500		\$ 17,000						\$ 9,000	3019	1
11	5	\$ 3,800	\$ 10,500								\$ 10,000	3019	1
12	Projects selected	1	0	1	1	0	0				\$ 11,000	3019	1
13	PW value at MARR	\$ 3,019	\$ (523)	\$ 874	\$ 804	\$ -	\$ -				\$ 12,000	3019	1
14	Contribution to Z	\$ 3,019	\$ -	\$ 874	\$ 803.81	\$ -	\$ -				\$ 13,000	3019	1
15	Investment	\$ 5,000	\$ -	\$ 9,000	\$ 10,000	\$ -	\$ -	Total =	\$ 24,000		\$ 14,000	3893	1,3
16											\$ 15,000	3893	1,3
17											\$ 16,000	3893	1,3
18											\$ 17,000	3893	1,3
19											\$ 18,000	3893	1,3
20											\$ 19,000	3893	1,3
21											\$ 20,000	3893	1,3
22											\$ 21,000	3893	1,3
23											\$ 22,000	3893	1,3
24											\$ 23,000	3893	1,3
25											\$ 24,000	4697	1,3,4
26											\$ 25,000	4697	1,3,4
27													
28													
29													
30													

12.26 (a) IROR: $0 = -325,000 + 60,000(P/A, i, 8)$

$$i^* = 9.6\%$$

$$\begin{aligned} PI &= 60,000(P/A, 15\%, 8) / |-325,000| \\ &= 60,000(4.4873) / 325,000 \\ &= 0.83 \end{aligned}$$

$$\begin{aligned} PW &= -325,000 + 60,000(P/A, 15\%, 8) \\ &= -325,000 + 60,000(4.4873) \\ &= \$-55,762 \end{aligned}$$

(b) No, since $IROR < 15\%$; $PI < 1.0$ and $PW < 0$ at $MARR = 15\%$

12.27 (a) Select projects A and B with a total of \$30,000 investment

$$\begin{aligned} \text{(b) Overall ROR} &= [20,000(20\%) + 10,000(19\%) + 9,000(13\%)] / 39,000 \\ &= 18.1\% \end{aligned}$$

12.28 (a) *Hand solution:* Find IROR for each project, rank by decreasing IROR and then select projects within budget constraint of \$97,000. RATE function used to find i^* values.

$$\text{For L: } 0 = -30,000 + 9000(P/A, i^*, 10) \\ i^* = 27.3\%$$

$$\text{For A: } 0 = -15,000 + 4,900(P/A, i^*, 10) \\ i^* = 30.4\%$$

$$\text{For N: } 0 = -45,000 + 11,100(P/A, i^*, 10) \\ i^* = 21.0\%$$

$$\text{For D: } 0 = -70,000 + 9000(P/A, i^*, 10) \\ i^* = 4.9\%$$

$$\text{For T: } 0 = -40,000 + 10,000(P/A, i^*, 10) \\ i^* = 21.4\%$$

Select projects A, L, and T with total investment of \$85,000

Spreadsheet solution: Fund A, L and T for \$85,000

	A	B	C	D	E	F	G	H
1	NCF, \$ per year							
2	Year	A	L	T	N	D		
3	0	-15,000	-30,000	-40,000	-45,000	-70,000		
4	1	4,900	9,000	10,000	11,100	9,000		
5	2	4,900	9,000	10,000	11,100	9,000		
6	3	4,900	9,000	10,000	11,100	9,000		
7	4	4,900	9,000	10,000	11,100	9,000		
8	5	4,900	9,000	10,000	11,100	9,000		
9	6	4,900	9,000	10,000	11,100	9,000		
10	7	4,900	9,000	10,000	11,100	9,000		
11	8	4,900	9,000	10,000	11,100	9,000		
12	9	4,900	9,000	10,000	11,100	9,000		
13	10	4,900	9,000	10,000	11,100	9,000		
14	IROR	30.4%	27.3%	21.4%	21.0%	4.9%		
15	Cumulative Investment, \$	15,000	45,000	85,000	130,000	200,000		

Sorted by
IROR

$$(b) \text{ ROR} = [15,000(30.4\%) + 30,000(27.3\%) + 40,000(21.4\%) + 12,000(15.0\%)]/97,000 \\ = 23.8\%$$

12.29 (a) *Hand :* Find ROR for each project and then select highest ones within budget constraint of \$100 million.

$$\text{For W: } 0 = -12,000 + 5000(P/A, i, 3) \\ i^* = 12.0\%$$

For X: $0 = -25,000 + 7,300(P/A, i, 4)$
 $i^* = 6.5\%$

For Y: $0 = -45,000 + 12,100(P/A, i, 6)$
 $i^* = 15.7\%$

For Z: $0 = -60,000 + 9,000(P/A, i, 8)$
 $i^* = 4.2\%$

Only two projects (W and Y) have rate of return \geq MARR = 12%. Project X not included since $i^*_X = 6.5\% < 12\% = \text{MARR}$.

Select Y and W with total investment of \$57 million.

Spreadsheet: Select Y and W after ranking (row 12); invest \$57 million. Project X not included since $i^*_X = 6.5\% < 12\% = \text{MARR}$.

	A	B	C	D	E	F	G
1	NCF, \$M per year						
2	Year	Y	W	X	Z		
3	0	-45	-12	-25	-60		
4	1	12.1	5.0	7.3	9.0		
5	2	12.1	5.0	7.3	9.0		
6	3	12.1	5.0	7.3	9.0		
7	4	12.1		7.3	9.0		
8	5	12.1			9.0		
9	6	12.1			9.0		
10	7				9.0		
11	8				9.0		
12	IROR	15.7%	12.0%	6.5%	4.2%		
13	Cumulative Investment, \$M	45	57	82	142		

Sorted by
IROR

(b) Find i^* of Y and W

NCF, year 0 = \$-57 million

NCF, years 1-3 = \$17.1 million

NCF, years 4-6 = \$12.1 million

$$0 = -57 + 17.1(P/A, i^*, 3) + 12.1(P/A, i^*, 3)(P/F, i^*, 3)$$

$$i^* = 15.1\% \quad (\text{IRR function})$$

(c) \$43 million was not committed; assume it makes MARR = 12% elsewhere.

$$\text{Overall ROR} = [57,000(15.1) + 43,000(12.0)]/100,000$$

$$= 13.8\%$$

$$\begin{aligned}
 \text{12.30} \quad \text{PW of NCF} &= (170,000 - 80,000)(P/A, 10\%, 5) + 60,000(P/F, 10\%, 5) \\
 &= (170,000 - 80,000)(3.7908) + 60,000(0.6209) \\
 &= \$378,426
 \end{aligned}$$

$$\begin{aligned}
 \text{PW of first cost} &= 200,000 + 200,000(P/F, 10\%, 1) \\
 &= 200,000 + 200,000(0.9091) \\
 &= \$381,820
 \end{aligned}$$

$$\begin{aligned}
 \text{PI} &= 378,426/381,820 \\
 &= 0.99
 \end{aligned}$$

$$\begin{aligned}
 \text{12.31 (a)} \quad \text{PI}_A &= 4000(P/A, 10\%, 10)/18,000 \\
 &= 4000(6.1446)/18,000 \\
 &= 1.37
 \end{aligned}$$

$$\begin{aligned}
 \text{PI}_B &= 2800(P/A, 10\%, 10)/15,000 \\
 &= 2800(6.1446)/15,000 \\
 &= 1.15
 \end{aligned}$$

$$\begin{aligned}
 \text{PI}_C &= 12,600(P/A, 10\%, 10)/35,000 \\
 &= 12,600(6.1446)/35,000 \\
 &= 2.21
 \end{aligned}$$

$$\begin{aligned}
 \text{PI}_D &= 13,000(P/A, 10\%, 10)/60,000 \\
 &= 13,000(6.1446)/60,000 \\
 &= 1.33
 \end{aligned}$$

$$\begin{aligned}
 \text{PI}_E &= 8000(P/A, 10\%, 10)/50,000 \\
 &= 8000(6.1446)/50,000 \\
 &= 0.98
 \end{aligned}$$

PI order	C	A	D	B
Cum Inv, \$1000	35	53	113	128

Select projects C, A, and D; invest \$113,000. E is eliminated with $\text{PI} < 1.0$

$$\text{(b)} \quad \begin{array}{ccccc}
 \text{IROR order} & \text{C} & \text{A} & \text{D} & \text{B} \\
 \hline
 \text{Cum Inv, \$1000} & 35 & 53 & 113 & 128
 \end{array}$$

Select C, A, and D; invest a total of \$113,000. E is eliminated with $\text{IROR} < 10\%$

(c) Selection and total investment are the same for PI and IROR ranking.

12.32 The IROR, PI, and PW values are shown below. Sample calculations for project F are:

$$\text{IROR: } 54,000/200,000 = 27.0\%$$

$$\text{PI: } [54,000/0.25]/200,000 = 1.08$$

$$\text{PW: } -200,000 + 54,000/0.25 = \$16,000$$

Projects G and K are eliminated since IROR, PI and PW are not acceptable.

(a) The projects selected by IROR are I, J, and H with \$670,000 invested

IROR rank	I	J	H	F
Cum Inv, \$1000	370	420	670	870

(b) The projects selected by PI are I, J, and H with \$670,000 invested

PI rank	I	J	H	F
Cum Inv, \$1000	370	420	670	870

(c) The projects selected by PW are I, H and J with \$670,000 invested

PW rank	I	H	J	F
Cum Inv, \$1000	370	620	670	870

Project	First Cost, \$	Annual Income, \$ per year	IROR, %	PI	PW, \$
F	-200,000	54,000	27.0	1.08	16,000
G	-120,000	21,000	17.5	0.70	-36,000
H	-250,000	115,000	46.0	1.84	210,000
I	-370,000	205,000	55.4	2.22	450,000
J	-50,000	26,000	52.0	2.08	54,000
K	-9000	2,100	23.3	0.93	-600

12.33 Answer is (d)

12.34 Answer is (b)

12.35 Answer is (a)

12.36 Answer is (c)

12.37 Maximum number of bundles = $2^5 = 32$

Answer is (d)

12.38 There are 5 possible bundles under the \$25,000 limit: P,Q,R,S, and PR. Largest PW is for project Q.

Answer is (b)

12.39 Answer is (a)

12.40 $PW \text{ of NCF} = 10,000(P/A, 10\%, 4)$
 $= 10,000(3.1699)$
 $= \$31,699$

$PI = 31,699/26,000$
 $= 1.22$

Answer is (b)

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 13
Breakeven and Payback Analysis

13.1 (a) $0 = -FC + (589 - 340)9000$
 $FC = \$2,241,000$ per year

(b) $P = -750,000 + (589 - 340)(7000)$
 $= \$993,000$ per year

13.2 (a) $Q_{BE} = 800,000 / (2950 - 2075)$
 $= 914$ units per year

(b) $P = (2950 - 2075)(3000) - 800,000$
 $= \$1,825,000$ per year

13.3 Let r = selling price per pound of recovered metals

$$0 = -12,000,000(A/P, 15\%, 15) - (2,600,000)0.71^{1.9} + 2,880(0.71)r$$
$$0 = -12,000,000(0.17102) - (2,600,000)0.522 + 2044.8r$$
$$r = \$1667 \text{ per pound}$$

13.4 France: $Q_{BE} = 3.5 \text{ million} / (8500 - 3900)$
 $= 761$ hwt

US: $Q_{BE} = 2.65 \text{ million} / (12,500 - 9,900)$
 $= 1019$ hwt

13.5 France: $Q_{BE} = 761 = 3.5 \text{ million} (1.10) / (r - 3900)$

$$r = 3.85 \text{ million} / 761 + 3900$$
$$= \$8959 \text{ per hwt}$$

US: $Q_{BE} = 1019 = 2.65 \text{ million} (1.10) / (r - 9900)$

$$r = 2.915 \text{ million} / 1019 + 9900$$
$$= \$12,761 \text{ per hwt}$$

13.6 France: Profit = $8500(950) - 3,500,000 - 3900(950)$
 $= \$870,000$

US: Profit = $12,500(850) - 2,650,000 - 9900(850)$
 $= \$-440,000$ (loss)

13.7 France: Profit = 1,000,000 = 8500(950) – 3,500,000 – v(950)

$$v = 3,575,000/950 \\ = \$3763 \text{ per hwt}$$

Reduction from \$3900 is \$137 or 3.5%

US: Profit = 1,000,000 = 12,500(850) – 2,650,000 – v(850)

$$v = 6,975,000/850 \\ = \$8205 \text{ per hwt}$$

Reduction from \$9900 is \$1695 or 17.1%

13.8 Gasoline required at 25.5 mpg = 1000/25.5 = 39.2 gallons

Gasoline required at 35.5 mpg = 1000/35.5 = 28.2 gallons

Gasoline saved = 39.2 – 28.2 = 11 gallons per month

Let c = cost of gasoline per gallon. To break even in 60 months

$$0 = -926 + 11c(P/A, 0.75\%, 60)$$

$$c = 926/11(48.1734) \\ = \$1.75 \text{ per gallon}$$

13.9 (a) $Q_{BE} = \frac{775,000}{2.50 - 1} = 516,667 \text{ calls per year}$

This is 37% of the center's capacity

(b) Set $Q_{BE} = 500,000$ and determine r at v = \$1 and FC = 0.5(900,000).

$$500,000 = \frac{450,000}{r - 1}$$

$$r - 1 = \frac{450,000}{500,000}$$

$$r = 0.9 + 1 = \$1.90 \text{ per call}$$

Average revenue required for the new product only is 60¢ per call lower.

13.10 Let m = miles driven per month to break even

$$\text{Gasoline cost savings} = 3.25/18 - 3.25/21 = \$0.0258/\text{mile}$$

$$800 = 0.0258m(P/A, 1\%, 36)$$

$$\begin{aligned} m &= 800/0.0258(30.1075) \\ &= 1030 \text{ miles/month} \end{aligned}$$

13.11 Added income for equipment from extra charges is

$$1421 - 758 - 400 = \$263 \text{ per patient}$$

$$\begin{aligned} P &= 263(50)(P/A, 10\%, 5) \\ &= 263(50)(3.7908) \\ &= \$49,849 \end{aligned}$$

13.12 Current cost per mile = $3.50/20 = \$0.175$ per mile

$$\text{Friction-reduced cost per mile} = 3.50/[(20)(1.25)] = \$0.140$$

$$\begin{aligned} 560(A/P, 10\%, 5) &= (0.175 - 0.140)x \\ 560(0.26380) &= (0.035)x \end{aligned}$$

$$\begin{aligned} 0.035x &= 147.73 \\ x &= 4221 \text{ miles per year} \end{aligned}$$

13.13 $[2.90/18]x$ miles = $(2.98 - 2.90)20$

$$\begin{aligned} 0.161x &= 1.60 \\ x &= 9.93 \text{ miles} \end{aligned}$$

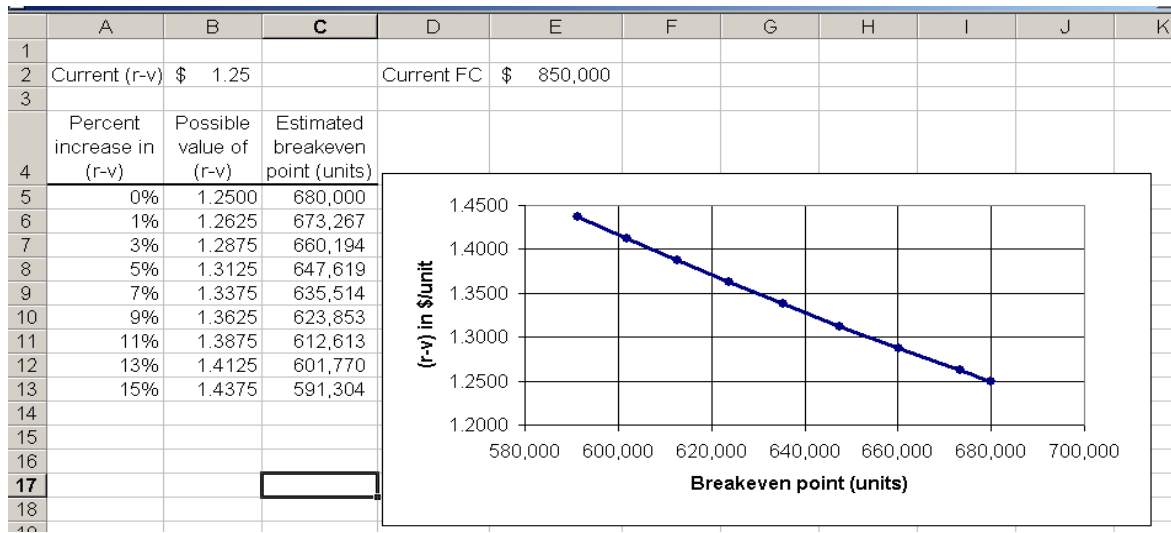
13.14 Let G = gradient increase per year. Set revenue = cost

$$\begin{aligned} [4000 + G(A/G, 12\%, 3)](33,000 - 21,000) &= -200,000,000(A/P, 12\%, 3) \\ &\quad + (0.20)(200,000,000)(A/F, 12\%, 3) \end{aligned}$$

$$\begin{aligned} [4000 + G(0.9246)](12,000) &= -200,000,000(0.41635) \\ &\quad + 40,000,000(0.29635) \end{aligned}$$

$$G = 2110 \text{ cars/year increase}$$

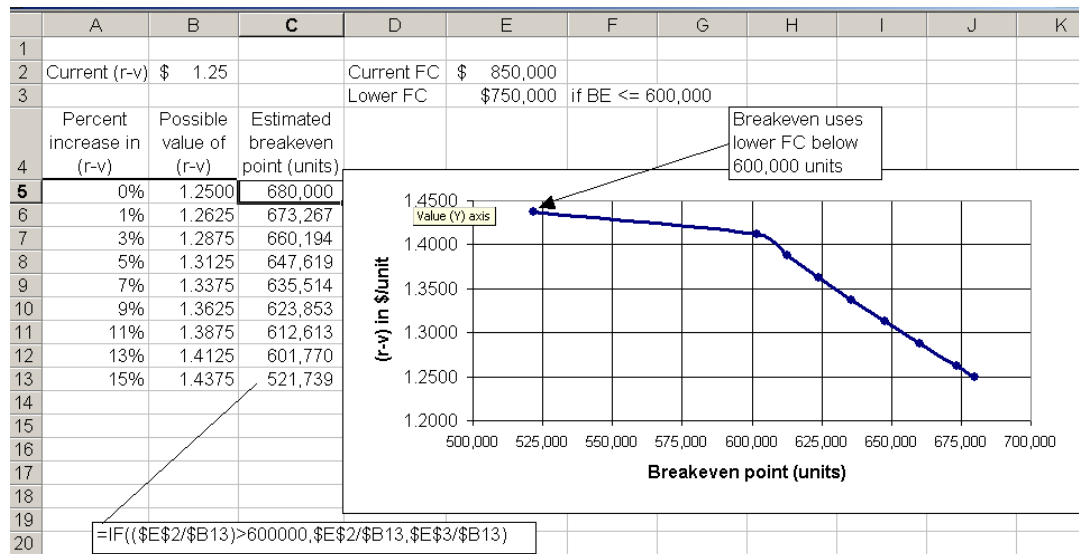
13.15 (a) Calculate $Q_{BE} = FC/(r-v)$ for (r-v) increases of 1% through 15% and plot.



The breakeven point decreases linearly from 680,000 currently to 591,304 if a 15% increase in (r-v) is experienced.

(b) If r and FC are constant, this means all the reduction must take place in a lower variable cost per unit.

13.16 Rework the spreadsheet above to include an IF statement for the computation of Q_{BE} for the reduced FC of \$750,000. The breakeven point falls substantially to 521,739 when the lower FC is in effect.



Note: To guarantee that the cell computations in column C correctly track when the breakeven point falls below 600,000, the same IF statement is used in all cells. With this feature, sensitivity analysis on the 600,000 estimate may also be performed.

13.17 Let x = number of portables per year

$$\begin{aligned}-7500x &= -218,000(A/P, 6\%, 20) - 12,000 \\ -7500x &= -218,000(0.08718) - 12,000 \\ -7500x &= -31,005 \\ x &= 4.1\end{aligned}$$

The city could afford four portable toilets per year

13.18 Equate AW relations for the two alternatives

$$\begin{aligned}P_{HDPE}(A/P, 6\%, 12) &= 1,800,000(A/P, 6\%, 6) + 375,000(P/F, 6\%, 4)(A/P, 6\%, 6) \\ P_{HDPE}(0.11928) &= 1,800,000(0.20336) + 375,000(0.7921)(0.20336) \\ P_{HDPE} &= \$3,575,231\end{aligned}$$

13.19 $VC_{excavator} = (15 + 1)/0.15 = \106.67 per mile
 $VC_{tiller} = [2(11) + 1.20]/0.04 = \580 per mile

$$\begin{aligned}FC_{excavator} &= -26,500(A/P, 10\%, 10) - 18,000 + 9,000(A/F, 10\%, 10) \\ &= -26,500(0.16275) - 18,000 + 9,000(0.06275) \\ &= \$-21,748 \text{ per year}\end{aligned}$$

$$\begin{aligned}FC_{tiller} &= -1200(A/P, 10\%, 5) \\ &= -1200(0.26380) \\ &= \$-316.56 \text{ per year}\end{aligned}$$

Equate the AW relations and let x = breakeven miles per year

$$\begin{aligned}-21,748 - 106.67x &= -316.56 - 580x \\ x &= 45.3 \text{ miles per year}\end{aligned}$$

13.20 $-(920 + 360)(A/P, 10\%, 3) - 3.10x = -3850(A/P, 10\%, 5) - 1.28x$
 $-1280(0.40211) - 3.10x = -3850(0.26380) - 1.28x$
 $1.82x = 500.93$
 $x = 275$ hours per year

13.21 (a) Solve the relation $AW_{buy} = AW_{make}$ for Q = number of units per year.

$$\begin{aligned}-25Q &= -150,000(A/P, 12\%, 5) + 15,000(A/F, 12\%, 5) - 35,000 - 5Q \\ -20Q &= -150,000(0.27741) + 15,000(0.15741) - 35,000 \\ Q &= -74,250/-20 \\ &= 3713 \text{ units per year}\end{aligned}$$

(b) Since $5000 > 3713$, select the make option. It has the smaller slope of 5 versus 25 for the buy option.

13.22 Equate PW relations; solve for P_S . Painting and blasting is not done at end of year 12.

$$\begin{aligned} -6500 - 6500(1.20)(P/F, 10\%, 4) - 6500(1.20)^2(P/F, 10\%, 8) &= -P_S - P_S(1.40)(P/F, 10\%, 6) \\ -6500 - 6500(1.20)(0.6830) - 6500(1.20)^2(0.4665) &= -P_S - P_S(1.40)(0.5645) \end{aligned}$$

$$1.79P_S = 16,193.84$$

$$P_S = \$9045$$

13.23 (a) Develop $PW = 0$ relation and solve for first cost P .

$$\text{I: } PW = -P + 0.2P(P/F, 8\%, 10) + 15,000(P/A, 8\%, 10)$$

$$0 = -P + 0.2P(0.4632) + 15,000(6.7101)$$

$$P = \$110,928$$

$$\text{II: } PW = -P + 0.2P(P/F, 8\%, 10) + 25,000(P/A, 8\%, 10) + 5000(P/G, 8\%, 10)$$

$$0 = -P + 0.2P(0.4632) + 25,000(6.7101) + 5000(25.9768)$$

$$P = \$328,025$$

(b) Spreadsheet solution uses Goal Seek to find P for each scenario.

	A	B	C	D	E	F	G
1	Year	I: No revenue	II: Outside Revenue	Total			
2	0	-110,927		-328,024			
3	1	15,000	10,000	25,000			
4	2	15,000	15,000	30,000			
5	3	15,000	20,000	35,000			
6	4	15,000	25,000	40,000			
7	5	15,000	30,000	45,000			
8	6	15,000	35,000	50,000			
9	7	15,000	40,000	55,000			
10	8	15,000	45,000	60,000			
11	9	15,000	50,000	65,000			
12	10	37,185	55,000	135,605			
13	PW	\$0		\$0			
14							

13.24 Let x = number of years for above-ground pool to last for break even

$$-400(A/P, 6\%, n) - 70 = -300(A/P, 6\%, 10) - 10(100)(A/P, 6\%, 10) - 20$$

$$-400(A/P, 6\%, n) - 70 = -300(0.13587) - 10(100)(0.13587) - 20$$

$$(A/P, 6\%, n) = 0.31658$$

From the 6% interest table, n is between 3 and 4 years; therefore, $n = 4$ years

13.25 (a) Solve the relation $PW_1 = PW_2$ for x miles

$$-500,000 - 100x(P/A, 6\%, 15) = -50,000 - [(130/0.05)x(1 + (P/A, 6\%, 15))]$$

$$-100(9.7122)x + 2600(1 + 9.7122)x = -50,000 + 500,000$$

$$x = 450,000/26,881$$

$$= 16.74 \text{ miles}$$

A spreadsheet solution involves the use of the Solver tool with a constraint that the two PW values be equal.

(b) Since $12.5 < 16.74$ miles, select alternative 2; it has the steeper slope.

13.26 (a) Let x = days per year to pump the lagoon. Set the AW relations equal.

$$\begin{aligned}-800(A/P, 10\%, 8) - 300x &= -1600(A/P, 10\%, 10) - 3x - 12(8200)(A/P, 10\%, 10) \\ -800(0.18744) - 300x &= -1600(0.16275) - 3x - 98,400(0.16275) \\ -149.95 - 300x &= -16275 - 3x \\ 297x &= 16125.05 \\ x &= 54.3 \text{ days per year}\end{aligned}$$

(b) If the lagoon is pumped 52 times per year and P = cost of pipeline, the breakeven equation becomes:

$$\begin{aligned}-800(0.18744) - 300(52) &= -1600(0.16275) - 3(52) + P(0.16275) \\ -15,750 &= -416.4 + 0.16275P \\ P &= \$-94,216\end{aligned}$$

13.27 (a) Solve the relation $AW_N = AW_A$ for H = number of hours per year.

$$\begin{aligned}-4000(A/P, 10\%, 3) - 1000(H/2000) - 1H &= -10,300(A/P, 10\%, 6) - 2200(H/8000) - 0.9H \\ (-.5 - 1 + 0.275 + 0.9)H &= -10,300(0.22961) + 4000(0.40211) \\ -0.325H &= -756.5 \\ H &= 2328 \text{ hours per year}\end{aligned}$$

Usage above 2328 hours will justify A since it has the smaller slope.

(b) Usage of $7(365) = 2555$ exceeds breakeven; select Auto Green (A). AW values are $AW_N = \$-5441$ and $AW_A = \$-5367$.

13.28 (a) Solve the relation $AW_{\text{lease}} - AW_{\text{buy}} = 0$ for N = number of months
Monthly $i = 1.25\%$.

$$-800 + 8500(A/P, 1.25\%, N) + 75 = 0$$

$$\text{For } N = 12: -800 + 8500(0.09026) + 75 = \$42.21$$

$$\text{For } N = 13: -800 + 8500(0.08382) + 75 = \$-12.53$$

$$N = 12.8 \text{ months} \quad (\text{interpolation})$$

(b) Spreadsheet function = NPER(1.25%, -725, 8500) displays 12.8 months. The -725 is the difference of the two monthly costs $-800 + 75 = -725$.

$$\begin{aligned}
 \mathbf{13.29} \quad AW_{\text{Volt}} &= -35,000(A/P, 0.75\%, 60) + 15,000(A/F, 0.75\%, 60) \\
 &= -35,000(0.02076) + 15,000(0.01326) \\
 &= \$-527.70
 \end{aligned}$$

$$\begin{aligned}
 AW_{\text{Leaf}} &= -500(A/P, 0.75\%, 60) - 349 \\
 &= -500(0.02076) - 349 \\
 &= \$-359.38
 \end{aligned}$$

$$\begin{aligned}
 AW_{\text{RA removal}} &= 527.70 - 359.38 \\
 &= \$168.32 \text{ per month}
 \end{aligned}$$

$$\mathbf{13.30} \text{ (a)} \quad n_p = 28,000 / (5000 - 1500) \\
 = 8 \text{ months}$$

$$\text{(b)} \quad 0 = -28,000 + (5000 - 1500)(P/A, 3\%, n_p)$$

$$\text{Try 8 months: } -28,000 + 3500(7.0197) = \$-3431$$

$$\text{Try 10 months: } -28,000 + 3500(8.5302) = \$1856$$

$$n = 9.3 \text{ months} \quad (\text{interpolation})$$

$$\begin{aligned}
 \text{(c)} \quad 0\% &:= \text{NPER}(0\%, 3500, -28000) \text{ displays 8.0 months} \\
 3\% &:= \text{NPER}(3\%, 3500, -28000) \text{ displays 9.3 months}
 \end{aligned}$$

$$\mathbf{13.31} \text{ (a)} \quad 0 = -28,000 + 2900(P/A, 8\%, n) + 1500(P/F, 8\%, n)$$

$$n = 15: \quad 0 = -28,000 + 2900(8.5595) + 1500(0.3152) = \$2705$$

$$n = 20: \quad 0 = -28,000 + 2900(9.8181) + 1500(0.2145) = \$-794$$

$$n_p = 18.7 \text{ years} \quad (\text{interpolation or NPER function})$$

(b) Since n is greater than the useful period of 12 years, the asset should not be purchased

$$\mathbf{13.32} \text{ (a)} \quad \text{Set } PW = 0 \text{ at given interest rates and solve for } n_p$$

$$0 = -3,150,000 + 500,000(P/A, i\%, n_p) + 400,000(P/F, i\%, n_p)$$

$$\begin{aligned}
 i = 0\%, n = 5: \quad PW &= -3,150,000 + 500,000(5) + 400,000 \\
 &= \$-250,000
 \end{aligned}$$

$$\begin{aligned}
 i = 0\%, n = 6: \quad PW &= -3,150,000 + 500,000(6) + 400,000 \\
 &= \$250,000
 \end{aligned}$$

$$n_p = 5.5 \text{ years} \quad (\text{interpolation})$$

$$i = 8\%, n = 8: \quad PW = -3,150,000 + 500,000(5.7466) + 400,000(0.5403) \\ = \$-60,580$$

$$i = 8\%, n = 9: \quad PW = -3,150,000 + 500,000(6.2469) + 400,000(0.5002) \\ = \$173,530$$

$$n_p = 8.2 \text{ years} \quad (\text{interpolation})$$

$$(b) \quad i = 15\%, n = 19: \quad PW = -3,150,000 + 500,000(6.1982) + 400,000(0.0703) \\ = \$-22,780$$

$$i = 15\%, n = 20: \quad PW = -3,150,000 + 500,000(6.2593) + 400,000(0.0611) \\ = \$4090$$

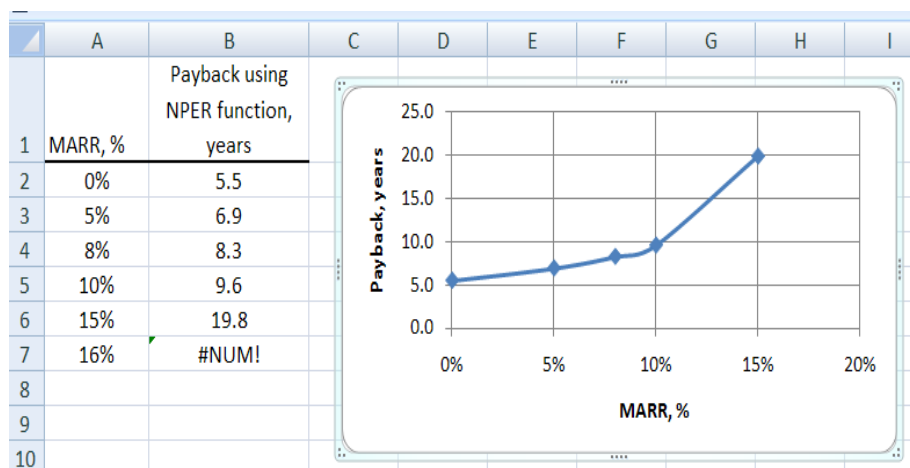
$$n_p = 19.8 \text{ years} \quad (\text{interpolation})$$

$$i = 16\%, n = 60: \quad PW = -3,150,000 + 500,000(6.2492) + 400,000(0.0001) \\ = \$-25,360$$

$$n_p > 60 \text{ years} \quad (\text{beyond tabulated } n \text{ values})$$

(Note: As $n \rightarrow \infty$, P/A goes to 6.25 and P/F goes to zero. Therefore, a 16% return is not possible, no matter how long the equipment is used.)

- (c) Spreadsheet shows nonlinear increase in payback as MARR increases. Note that at 16%, the payback cannot be calculate by the NPER function; it is too large for the function. (See note above.)



13.33 (a) Set $PW = 0$ and solve for n_p

$$0 = -1050 + 600(P/F, 10\%, n_p) + 175(P/A, 10\%, n_p) + 45(P/G, 10\%, n_p)$$

$$\text{For } n = 3: PW = \$-59$$

$$\text{For } n = 4: PW = \$111.50$$

$$n_p = 3.3 \text{ years} \quad (\text{interpolation})$$

(b) The equipment should be purchased, since $3.3 < 7$ years

13.34 $-250,000 - 500n + 250,000(1 + 0.02)^n = 100,000$

$$\text{Try } n = 18: 98,062 < 100,000$$

$$\text{Try } n = 19: 104,703 > 100,000$$

$$n_p \text{ is } 18.3 \text{ months or } 1.6 \text{ years}$$

13.35 (a) Cash flows sum to \$139,100, which exceeds the \$75,000 first cost by 85%.

(b) Solve $PW = 0$ relation for i^*

$$PW = -75,000 - 10,500(P/F, i^*, 1) + \dots + 105,000(P/F, i^*, 5) = 0$$

$$i^* = 13.96\% \quad (\text{IRR function})$$

(c) Calculate PW at 7% by year to determine when PW turns positive. Start with $n = 3$ years.

$$\begin{aligned} n = 3: PW &= -75,000 - 10,500(P/F, 7\%, 1) + 18,600(P/F, 7\%, 2) - 2000(P/F, 7\%, 3) \\ &= -75,000 - 10,500(0.9346) + 18,600(0.8734) - 2000(0.8163) \\ &= \$-70,201 \end{aligned}$$

$$\begin{aligned} n = 4: PW &= -70,201 + 28,000(P/F, 7\%, 4) \\ &= \$-48,840 \end{aligned}$$

$$\begin{aligned} n = 5: PW &= -48,840 + 105,000(P/F, 7\%, 5) \\ &= \$26,025 \end{aligned}$$

Investment is paid back plus 7% during year 5, in part due to large cash flow at sale time. A spreadsheet solution for all three parts follows.

	A	B	C	D	E	F	G
1	Year	NCF		(c) PW @ 7%			
2	0	-75,000		-			
3	1	-10,500		-84,813		= NPV(7%,B\$3:B3)+B\$2	
4	2	18,600		-68,567			
5	3	-2,000		-70,200			
6	4	28,000		-48,839			
7	5	105,000		26,025		= NPV(7%,B\$3:B7)+B\$2	
8	(a) Sum	139,100					
9	(b) ROR	13.96%					
10							
11							

13.36 (a) Calculate capital return (CR) at a 5% return. $S = 0$.

$$\begin{aligned}
 n = 3: \text{CR} &= -45,000(A/P, 5\%, 3) \\
 &= -45,000(0.36721) \\
 &= \$-16,524 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 n = 5: \text{CR} &= -45,000(A/P, 5\%, 5) \\
 &= \$-10,394 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 n = 8: \text{CR} &= -45,000(A/P, 5\%, 8) \\
 &= \$-6,962 \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 n = 10: \text{CR} &= -45,000(A/P, 5\%, 10) \\
 &= \$-5,828 \text{ per year}
 \end{aligned}$$

For spreadsheet solution, progressively enter $=\text{PMT}(5\%, n, -45000)$ into cells for $n = 3, 5, 8$ and 10 years.

(b) For payback $n_p = 10$ years and a 5% return, find PW.

$$\begin{aligned}
 \text{PW} &= 5000(P/A, 5\%, 10) \\
 &= -5000(7.7217) \\
 &= \$38,609
 \end{aligned}$$

13.37 Monthly $i = 9/12 = 0.75\%$. Solve PW relations for n_p

$$\begin{aligned}
 \text{(a) Purchase:} \quad \text{PW} &= -30,000 + 3500(P/A, 0.75\%, n_p) \\
 (P/A, 0.75\%, n_p) &= 8.5714
 \end{aligned}$$

$$n_p = 8.9 \text{ months} \quad (\text{interpolation})$$

For spreadsheet solution, enter $=\text{NPER}(0.75\%, 3500, -30000)$ to display 8.9

$$\text{(b) Lease:} \quad \text{PW} = -10,000[1 + (P/F, 0.75\%, 12)] + 2000(P/A, 0.75\%, n_p)$$

Since \$2000 per month will payback during the first year, the second \$10,000 can be neglected.

$$\begin{aligned}PW &= -10,000 + 2000(P/A, 0.75\%, n_p) \\ (P/A, 0.75\%, n) &= 5.0\end{aligned}$$

$$n = 5.1 \text{ months} \quad (\text{interpolation})$$

For spreadsheet solution, enter = NPER(0.75%,2000,-10000) to display 5.1

13.38 (a) Sum NCF for n months until it turns positive. Payback between 6 and 7 months.

$$n = 6: \text{Sum} = -15,000 - 2(2000) + 2(1000) + 2(6000) = \$-5000$$

$$n = 7: \text{Sum} = -15,000 - 2(2000) + 2(1000) + 3(6000) = \$1000$$

(b) Monthly $i = 1.5\%$. Solve for n_p in PW relation. Payback just over 7 months.

$$\begin{aligned}n = 7: PW &= -15,000 - 2000(P/A, 1.5\%, 2) + 1000(P/A, 1.5\%, 2)(P/F, 1.5\%, 2) \\ &\quad + 6000(P/A, 1.5\%, 3)(P/F, 1.5\%, 4) \\ &= \$-550\end{aligned}$$

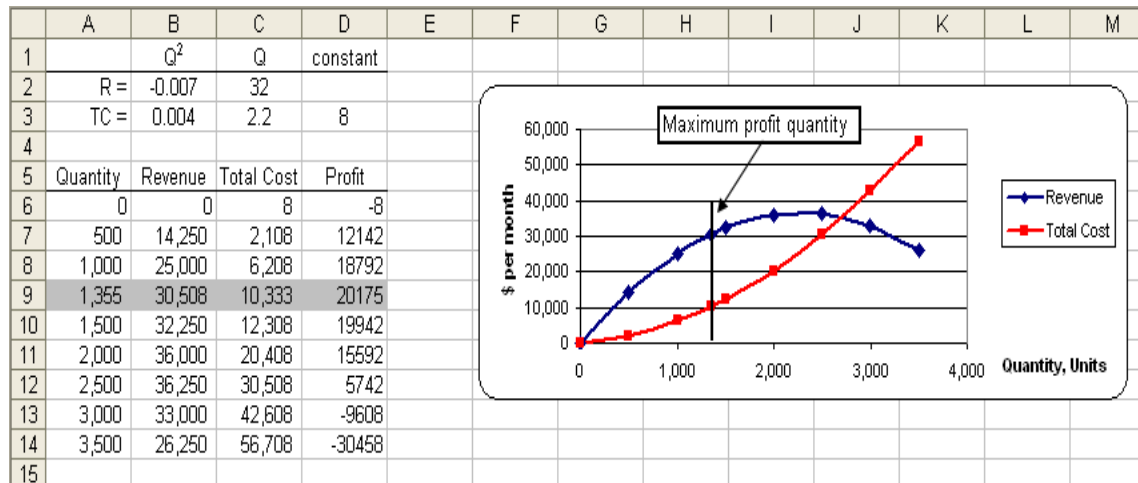
$$\begin{aligned}n = 8: PW &= -15,000 - 2000(P/A, 1.5\%, 2) + 1000(P/A, 1.5\%, 2)(P/F, 1.5\%, 2) \\ &\quad + 6000(P/A, 1.5\%, 3)(P/F, 1.5\%, 4) + 9000(P/F, 1.5\%, 8) \\ &= \$7439\end{aligned}$$

$$\text{Payback is } n_p = 7.1 \text{ months} \quad (\text{interpolation})$$

13.39 Since cash flows after n_p are neglected in payback analysis, an alternative that produces a higher return due to cash flows after the payback period may be rejected in favor of one with a shorter payback period. In reality, the lower-payback alternative is not as profitable from the rate of return perspective.

13.40 No-return payback neglects both the time value of money and all cash flows after the 0% payback period. Alternatives that don't payback at 0% may be acceptable if the cash flows estimated to occur after n_p are considered. Thus, a PW or AW analysis at the MARR is a better evaluation method for an alternative over its entire expected life.

13.41 (a) Plot shows maximum quantity at about 1350 units. Profit estimate is \$20,175



$$(b) \text{ Profit} = R - TC = (-.007-.004) Q^2 + (32-2.2)Q - 8$$

$$= -.011Q^2 + 29.8Q - 8$$

$$Q_p = -b/2a = -29.8/2(-.011)$$

$$= 1355 \text{ units}$$

$$\text{Profit} = -b^2/4a + c = -29.8^2 / 4(-.011) - 8$$

$$= \$20,175$$

13.42 Let R = revenue for years 2 through 8. Set up PW = 0 relation.

$$PW = \text{Revenue} - \text{costs}$$

$$0 = 50,000(P/F, 10\%, 1) + R(P/A, 10\%, 7)(P/F, 10\%, 1)$$

$$-150,000 + 20,000(P/F, 10\%, 8) - 42,000(P/A, 10\%, 8)$$

$$R = \frac{-50,000(0.9091) + 150,000 - 20,000(0.4665) + 42,000(5.3349)}{(4.8684)(0.9091)}$$

$$= \$319,281 / 4.4259$$

$$= \$72,140 \text{ per year}$$

Spreadsheet solution uses Goal Seek to find R = \$72,141 with remaining revenue cells set equal to this value.

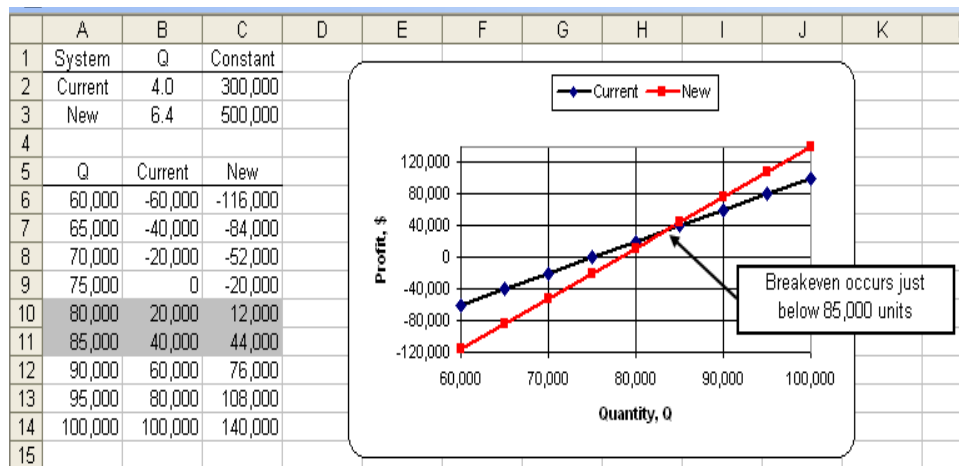
	A	B	C	D	E	F
1	Year	Costs	Revenues	Net cash flow		
2	0	-150000		-150000		
3	1	-42000	50000	8000		
4	2	-42000	72141	30141		GOAL SEEK result
5	3	-42000	72141	30141		
6	4	-42000	72141	30141		
7	5	-42000	72141	30141		
8	6	-42000	72141	30141		
9	7	-42000	72141	30141		
10	8	-42000	92141	50141		
11	PW			\$0		
12			All cells are =C\$4	=C\$4+20000		
13						
14						

13.43 (a) Current: $Q_{BE} = 300,000 / (14 - 10) = 75,000$ units

(b) New: $Q_{BE} = 500,000 / [16 - 48(0.2)] = 78,125$ units

13.44 Current: Profit = $14Q - 300,000 - 10Q = 4Q - 300,000$

New: Profit = $16Q - 500,000 - 9.60Q = 6.4Q - 500,000$



13.45 Solve the relation $AW_I = AW_O$ for N = number of tests per year

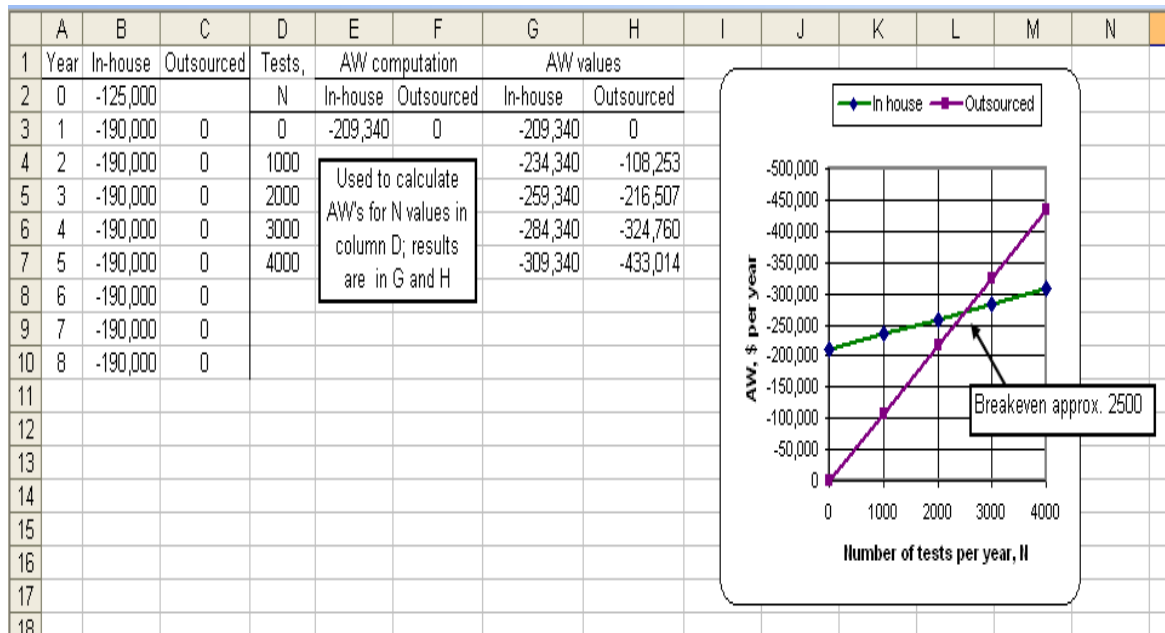
$$-125,000(A/P, 5\%, 8) - 190,000 - 25N = -100N - 25N(F/A, 5\%, 3)(A/F, 5\%, 8)$$

$$[75 + 25(3.1525)(0.10472)]N = 125,000(0.15472) + 190,000$$

$$83.25N = 209,340$$

$$N = 2514 \text{ tests per year}$$

13.46 Spreadsheet used to calculate AW values for each N value; recorded in columns G and H using 'Paste Values' function and then plotted.



13.47 It will raise the breakeven point. Outsourcing will cost \$75, increasing to \$93.75 in years 6- 8. Resolve for N.

$$\begin{aligned}
 -125,000(A/P, 5\%, 8) - 190,000 - 25N &= -75N - 18.75N(F/A, 5\%, 3)(A/F, 5\%, 8) \\
 [50 + 18.75(3.1525)(0.10472)]N &= 125,000(0.15472) + 190,000 \\
 56.19N &= 209,340 \\
 N &= 3726 \text{ tests per year}
 \end{aligned}$$

13.48 It will decrease the breakeven point. Resolve for N.

$$\begin{aligned}
 -125,000(A/P, 5\%, 8) - 115,000 - 20N &= -100N - 25N(F/A, 5\%, 3)(A/F, 5\%, 8) \\
 [80 + 25(3.1525)(0.10472)]N &= 125,000(0.15472) + 115,000 \\
 88.25N &= 134,340 \\
 N &= 1522 \text{ tests per year}
 \end{aligned}$$

13.49 Answer is (c)

13.50 Answer is (b)

13.51 Answer is (c)

13.52 $-23,000(A/P, 10\%, 10) + 4000(A/F, 10\%, 10) - 3000 - 3x = -8,000(A/P, 10\%, 4) - 2000 - 6x$
 $3x = -8000(0.31547) + 1000 + 23,000(0.16275) - 4000(0.06275)$
 $x = 656$

Answer is (d)

$$\begin{aligned}
13.53 \quad -100N &= -250,000(A/P, 15\%, 4) - 80,000 - 40N \\
60N &= 250,000(0.35027) + 80,000 \\
N &= 2793
\end{aligned}$$

Since slope of Make is lower, Make would be cheaper above breakeven point

Answer is (b)

$$\begin{aligned}
13.54 \quad -10,000 - 50x &= -21,500 - 10x \\
x &= 287.5
\end{aligned}$$

Answer is (a)

13.55 Both the fixed and variable costs are lower for Y; Y is better

Answer is (a)

$$\begin{aligned}
13.56 \quad -100,000(A/P, 6\%, 10) - 10,000 &= -30,000(A/P, 6\%, 5) - x \\
-100,000(0.13587) - 10,000 &= -30,000(0.23740) - x \\
x &= 16,465
\end{aligned}$$

Answer is (c)

$$\begin{aligned}
13.57 \quad -50,000(A/P, 8\%, 5) - 100x &= -400x \\
-50,000(0.25046) - 100x &= -400x \\
x &= 41.7 \text{ days}
\end{aligned}$$

Answer is (b)

13.58 Answer is (b)

13.59 Set AW relations equal and solve for x, the cost of the enamel coating

$$\begin{aligned}
-5000(A/P, 8\%, 5) - 1000(P/F, 8\%, 3)(A/P, 8\%, 5) &= x(A/P, 8\%, 2) \\
-5000(0.25046) - 1000(0.7938)(0.25046) &= x(0.56077) \\
x &= \$2588
\end{aligned}$$

Answer is (c)

$$13.60 \quad 50,000 + 2400n_p = 25,000(F/P, 20\%, n_p)$$

Solve for n_p

$$n_p = 4.99 \text{ years}$$

Answer is (b)

$$\begin{aligned} 13.61 \quad -16,000 - 40(1000) &= -FC - (125/5)(1000) \\ FC &= \$31,000 \end{aligned}$$

Answer is (d)

$$\begin{aligned} 13.62 \quad \text{Breakeven: } -500,000 &= (250 - 200)x \\ x &= 10,000 \text{ units} \end{aligned}$$

20% above = 12,000 units

Answer is (b)

$$\begin{aligned} 13.63 \quad VC_B &= 40(4)/8 \\ &= \$20 \text{ per mile} \end{aligned}$$

Answer is (c)

$$\begin{aligned} 13.64 \quad -28,000(A/P, 10\%, n) + 5000 - 1500 &= 0 \\ (A/P, 10\%, n) &= 3500/28,000 \\ &= 0.125 \end{aligned}$$

n = 16.9 years

Answer is (d)

Solution to Case Study, Chapter 13

Sometimes, there is not a definitive answer to a case study exercise. Here are example responses.

WATER TREATMENT PLANT PROCESS COSTS

1. Savings = $40 \text{ hp} * 0.75 \text{ kw/hp} * 0.12 \text{ \$/kwh} * 24 \text{ hr/day} * 30.5 \text{ days/mo} \div 0.90$
= \$2928 per month
2. A decrease in the efficiency of the aerator motor renders the selected alternative of “sludge recirculation only” *more* attractive, because the cost of aeration would be higher, and, therefore the net savings from its discontinuation would be greater.
3. If the cost of lime increased by 50%, the lime costs for “sludge recirculation only” and “neither aeration nor sludge recirculation” would increase by 50% to \$393 and \$2070, respectively. Therefore, the cost difference would *increase*.
4. If the efficiency of the sludge recirculation pump decreased from 90% to 70%, the net savings between alternatives 3 and 4 would *decrease*. This is because the \$262 saved by not recirculating with a 90% efficient pump would increase to a monthly savings of \$336 by not recirculating with a 70% efficient pump.
5. If hardness removal were discontinued, the extra cost for its removal (column 4 in Table 13-1) would be zero for all alternatives. The favored alternative under this scenario would be alternative 4 (neither aeration nor sludge recirculation) with a total savings of $\$2,471 - 469 = \2002 per month.
6. If the cost of electricity decreased to 8¢/kwh, the aeration only and sludge recirculation only monthly costs would be \$244 and \$1952, respectively. The net savings for alternative 2 would then be \$-1605, alternative 3 would save \$845, and alternative four would save \$347. Therefore, the best alternative continues to be number 3.
7. (a) For alternatives 1 and 2 to breakeven, the total savings would have to be equal to the total extra cost of \$1,849. Thus,

$$1,849 / 30.5 = (5)(0.75)(x)(24) / 0.90$$
$$x = 60.6 \text{ cents per kwh}$$

$$(b) \quad 1107 / 30.5 = (40)(0.75)(x)(24) / 0.90$$
$$x = 4.5 \text{ cents per kwh}$$

$$(c) \quad 1,849 / 30.5 = (5)(0.75)(x)(24) / 0.90 + (40)(0.75)(x)(24) / 0.90$$
$$x = 6.7 \text{ cents per kwh}$$

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 14
Effects of Inflation

14.1 (a) There is no difference.

(b) Today's dollars are inflated compared to dollars of 2 years ago. Therefore, in order for the dollars to have the same value (i.e., constant-value dollars) as 2 years ago, divide today's dollars by $(1 + f)^2$.

14.2 (a) During periods of inflation

(b) During periods of deflation

(c) When inflation is zero

14.3 $0.10 = 0.04 + f + 0.04f$

$$1.04f = 0.06$$

$$f = 0.0577 \text{ or } 5.77\% \text{ per year}$$

14.4 $i_f = 0.20 + 0.05 + (0.20)(0.05)$

$$= 0.26 \text{ or } 26\%$$

14.5 $i_f \text{ per month} = 0.30/12 + 0.015 + (0.30/12)(0.015)$

$$= 0.040375 \text{ or } 4.0375\% \text{ per month}$$

$$\text{Nominal } i_f \text{ per year} = 12(4.0375)$$

$$= 48.45\% \text{ per year}$$

14.6 $0.35 = 0.25 + f + 0.25f$

$$1.25f = 0.10$$

$$f = 0.08 \text{ or } 8\% \text{ per year}$$

14.7 $i_f = 0.04 + 0.01 + (0.04)(0.01)$

$$= 0.0504 \text{ or } 5.04\% \text{ per quarter}$$

14.8 $i_f \text{ per month} = 18/12 = 1.5\%$

Use inflation-adjusted interest rate equation to solve for i .

$$0.015 = i + 0.005 + (i)(0.005)$$

$$1.005i = 0.01$$

$$i = 0.00995 \text{ or } 0.995\% \text{ per month}$$

14.9 Let CV = constant-value dollars

$$CV_1 = 45,000/(1 + 0.05)^1 = \$42,857$$

$$CV_2 = 45,000/(1 + 0.05)^2 = \$40,816$$

$$CV_3 = 45,000/(1 + 0.05)^3 = \$38,873$$

$$CV_4 = 45,000/(1 + 0.05)^4 = \$37,022$$

14.10 Future, inflated dollars = $10,000(1 + 0.05)^{10} = \$16,289$

14.11 Number of future dollars required = $1,500,000(1 + 0.04)^{30}$
= \$4,865,096

14.12 Assume C_1 is the cost today

$$2C_1 = C_1(1 + 0.07)^n$$

$$(1 + 0.07)^n = 2.000$$

$$n \log 1.07 = \log 2.000$$

$$n = 10.2 \text{ years}$$

14.13 $0.28 = i + 0.06 + i(0.06)$

$$1.06i = 0.22$$

$$i = 0.2075 \text{ or } 20.75\%$$

14.14 (a) Inflation rate, $f = [(2472.4 - 113.6)/113.6] \times 100$
= 2076% per year

(b) Monthly inflation rate $f = 2076/12 = 173\%$ per month

Daily inflation rate $f = 2076/365 = 5.68\%$ per day

14.15 Buying power = $250,000/(1 + 0.04)^5$
= \$205,482

14.16 (a) Constant-value dollars have to increase by only the real interest rate of 5% per year.

$$CV_5 = 30,000(F/P, 5\%, 5)$$

$$= 30,000(1.2763)$$

$$= \$38,289$$

(b) $i_f = 0.05 + 0.04 + (0.05)(0.04)$

$$= 9.2\%$$

$$F = 30,000(F/P, 9.2\%, 5) = 30,000(1.55279)$$

$$= \$46,584$$

14.17 Find f using F/P or P/F factor

$$5400 = 4050(F/P, f, 5)$$
$$(F/P, f, 5) = 1.3333$$

By factor equation

$$(1 + f)^5 = 1.3333$$

$$1 + f = 1.3333^{0.2}$$

$$1 + f = 1.0592$$

$$f = 0.0592 \text{ or } 5.92\% \text{ per year}$$

14.18 Price next year $= 28,000(1 + 0.021)^1$
 $= \$28,588$

Price in 3 years $= 28,000(1 + 0.021)^3$
 $= \$29,801$

14.19 (a) Cost in today's dollars $= \$120,000$

(b) Cost in future dollars $= 120,000(1 + 0.028)^2$
 $= \$126,814$

14.20 If price had increased only by inflation rate,

$$\text{Cost} = 29,000(1 + 0.03)^5$$
$$= \$33,619$$

The salesman was not telling the truth.

14.21 (a) Cost of T & F $= 0.28(52,000) = \$14,560$

(b) Cost of T & F 25 years ago $= 14,560 / (1 + 4.39) = \2701

(c) MFI 25 years ago $= 52,000 / (1 + 1.47) = \$21,053$
% of MFI 25 years ago $= 2701 / 21,053 = 12.8\%$

14.22 (a) At a 58% increase, \$1 would increase to \$1.58. Let x = annual percentage increase

$$1.58 = (1 + x)^5$$
$$1.58^{0.2} = 1 + x$$
$$1.096 = 1 + x$$
$$x = 0.096 \text{ or } 9.6\% \text{ per year}$$

(b) $0.096 = 0.05 + f + 0.05f$
 $1.05f = 0.046$
 $f = 4.38\% \text{ per year}$

$$\begin{aligned}
 14.23 \quad P_g &= 350\{1 - [(1+0.03/1 + 0)^{31}]/0 - 0.03\} \\
 &= 350(50) \\
 &= \$17,500
 \end{aligned}$$

$$\begin{aligned}
 \text{Savings} &= 17,500 - 350(31) \\
 &= \$6650
 \end{aligned}$$

or

$$\begin{aligned}
 \text{Savings} &= 350(F/A, 3\%, 31) - 350(31) \\
 &= 350(50.0027) - 10,850 \\
 &= \$6651
 \end{aligned}$$

14.24 The two ways to account for inflation in PW calculations are:

- (1) Convert all cash flow amounts into constant-value (CV) dollars, and
- (2) Change the interest rate to consider inflation, that is, to account for the changing currency value.

$$\begin{aligned}
 14.25 \quad i_f &= 0.10 + 0.04 + (0.10)(0.04) \\
 &= 14.4\%
 \end{aligned}$$

$$\begin{aligned}
 \text{PW} &= 50,000(P/F, 14.4\%, 2) \\
 &= 50,000[1/(1.144)^2] \\
 &= \$38,205
 \end{aligned}$$

$$\begin{aligned}
 14.26 \quad i_f &= 0.10 + 0.04 + (0.10)(0.04) \\
 &= 14.4\%
 \end{aligned}$$

$$\begin{aligned}
 \text{PW} &= 125,000(P/F, 14.4\%, 3) \\
 &= 125,000(0.66792) \\
 &= \$83,490
 \end{aligned}$$

$$\begin{aligned}
 14.27 \quad i_f &= 0.12 + 0.03 + (0.12)(0.03) \\
 &= 15.36\%
 \end{aligned}$$

$$\begin{aligned}
 \text{PW} &= 75,000(P/F, 15.36\%, 4) \\
 &= 75,000[1/(1.1536)^4] \\
 &= 75,000(0.56465) \\
 &= \$42,349
 \end{aligned}$$

14.28 Convert all cash flows into CV dollars and then use i.

$$\begin{aligned}
 \text{PW} &= 3000(P/F, 8\%, 1) + [6000/(1 + 0.06)^2](P/F, 8\%, 2) \\
 &\quad + [8000/(1 + 0.06)^3](P/F, 8\%, 3) + 4000(P/F, 8\%, 4) \\
 &\quad + 5000(P/F, 8\%, 5) \\
 &= 3000(0.9259) + 5340(0.8573) + 6717(0.7938) \\
 &\quad + 4000(0.7350) + 5000(0.6806) \\
 &= \$19,031
 \end{aligned}$$

14.29 The \$1.9 million are then-current dollars. Use i_f to find PW

$$i_f = 0.15 + 0.03 + (0.15)(0.03) = 18.45\%$$

$$\begin{aligned}PW &= 1,900,000(P/F, 18.45\%, 3) \\&= 1,900,000[(1/(1 + 0.1845))^3] \\&= \$1,143,269\end{aligned}$$

14.30 (a) Use $i = 10\%$

$$\begin{aligned}F &= 68,000(F/P, 10\%, 2) \\&= 68,000(1.21) \\&= \$82,280\end{aligned}$$

Purchase later for \$81,000

(b) Use $i_f = 0.10 + 0.05(0.10)(0.05)$

$$\begin{aligned}F &= 68,000(F/P, 15.5\%, 2) \\&= 68,000(1 + 0.155)^2 \\&= 68,000(1.334) \\&= \$90,712\end{aligned}$$

Purchase later for \$81,000

14.31 Use the real i for salesman A and inflated i_f for Salesman B.

$$i_f = 0.20 + 0.04 + (0.20)(0.04) = 24.8\%$$

$$\begin{aligned}PW_A &= -140,000 - 25,000(P/A, 20\%, 10) \\&= -140,000 - 25,000(4.1925) \\&= \$-244,812\end{aligned}$$

$$\begin{aligned}PW_B &= -155,000 - 40,000(P/A, 24.8\%, 10) \\&= -155,000 - 40,000(3.5923) \\&= \$-298,692\end{aligned}$$

Recommend purchase from salesman A

14.32 $i_f = 0.12 + 0.04 + (0.12)(0.04)$
 $= 16.48\%$

$$\begin{aligned}PW_{IWS} &= 2,100,000(P/F, 16.48\%, 2) \\&= 2,100,000[(1/(1 + 0.1648))^2] \\&= 2,100,000(0.73705) \\&= \$1,547,806\end{aligned}$$

$$PW_{AG} = \$1,700,000$$

Select IWS

$$14.33 \quad i_f \text{ per month} = 0.01 + 0.004 + (0.01)(0.004) = 1.4\%$$

$$\begin{aligned} PW_S &= 2,300,000(P/F, 1.4\%, 120) \\ &= 2,300,000[(1/(1 + 0.014)^{120}] \\ &= \$433,684 \end{aligned}$$

$$\begin{aligned} PW_L &= 2,500,000(P/F, 1.4\%, 120) \\ &= 2,500,000[(1/(1 + 0.014)^{120}] \\ &= \$471,395 \end{aligned}$$

14.34 Find present worth of all three plans.

$$\text{Method 1: } PW_1 = \$480,000$$

$$\text{Method 2: } i_f = 0.10 + 0.06 + (0.10)(0.06) = 16.6\%$$

$$\begin{aligned} PW_2 &= 1,100,000(P/F, 16.6\%, 5) \\ &= 1,100,000(0.46399) \\ &= \$510,389 \end{aligned}$$

$$\begin{aligned} \text{Method 3: } PW_3 &= 850,000(F/P, 6\%, 5)(P/F, 16.6\%, 5) \\ &= \$850,000(1.3382)(0.46399) \\ &= \$527,775 \end{aligned}$$

CCS should select payment method 3

$$\begin{aligned} 14.35 \quad i_f &= 0.10 + 0.06 + (0.10)(0.06) \\ &= 16.6\% \text{ per year} \end{aligned}$$

$$\begin{aligned} F &= 10,000(F/P, 16.6\%, 10) \\ &= 10,000(1 + 0.166)^{10} \\ &= \$46,450 \end{aligned}$$

14.36 Find F in future dollars using $f = -3.0\%$

$$\begin{aligned} F &= 50,000(1 - 0.03)^5 \\ &= 50,000(0.85873) \\ &= \$42,937 \end{aligned}$$

$$\begin{aligned} 14.37 \quad \text{Purchasing power} &= 100,000(F/P, 10\%, 15)/(1 - 0.01)^{15} \\ &= 100,000(4.1772)/0.86006 \\ &= \$485,687 \end{aligned}$$

$$\begin{aligned}
 \text{14.38 Buying power} &= 60,000(F/A, 10\%, 5)/(1 + 0.04)^5 \\
 &= 60,000(6.1051)/1.21665 \\
 &= \$301,078
 \end{aligned}$$

$$\begin{aligned}
 \text{14.39 } 8,000,000(1 + f)^4 &= 7,000,000(F/P, 7\%, 4) \\
 8,000,000(1 + f)^4 &= 7,000,000(1.3108) \\
 8,000,000(1 + f)^4 &= 9,175,600 \\
 (1 + f)^4 &= 1.14695 \\
 4[\log(1 + f)] &= \log 1.14695 \\
 4[\log(1 + f)] &= 0.05954 \\
 \log(1 + f) &= 0.01489 \\
 1 + f &= 10^{0.01489} \\
 1 + f &= 1.03487 \\
 f &= 3.487\% \text{ per year}
 \end{aligned}$$

$$\begin{aligned}
 \text{14.40 (a) } 25,000 &= 10,000(F/P, i, 5) \\
 (F/P, i, 5) &= 2.5000
 \end{aligned}$$

$$i = 20.1\% \quad (\text{solve } F/P \text{ equation, interpolation or RATE function})$$

$$\begin{aligned}
 \text{(b) } 0.201 &= i + 0.04 + i(0.04) \\
 1.04i &= 0.161 \\
 i &= 15.48\%
 \end{aligned}$$

$$\begin{aligned}
 \text{(c) Buying power} &= 25,000/(1 + 0.04)^5 \\
 &= \$20,548
 \end{aligned}$$

$$\begin{aligned}
 \text{14.41 Cost} &= (3)32,350(1 + 0.035)^2 \\
 &= \$103,962
 \end{aligned}$$

$$\begin{aligned}
 \text{14.42 (a) } 1,400,000 &= 653,000(1 + f)^{13} \\
 (1 + f)^{13} &= 2.14395 \\
 f &= 6.04\%
 \end{aligned}$$

$$\text{(b) The market rate is } f + 5\%.$$

$$\begin{aligned}
 i_f &= 0.03 + 0.05 \\
 F &= 1,400,000(1.08)^{11} \\
 &= \$3,264,295
 \end{aligned}$$

$$\begin{aligned}
 \text{14.43 } i_f &= 0.15 + 0.028 + (0.15)(0.028) \\
 &= 18.22\%
 \end{aligned}$$

$$\begin{aligned}
 F &= 2,400,000(F/P, 18.22\%, 3) \\
 &= 2,400,000(1 + 0.1822)^3 \\
 &= \$3,965,374
 \end{aligned}$$

14.44 (a) Cost, year 20: machine A = $10,000(1.10)(1.10)(1.02)(1.02)\dots(1.02)$
 $= \$31,617.58$

Cost, year 20: machine B = $10,000(1.02)(1.02)(1.10)(1.10)\dots(1.10)$
 $= \$31,617.58$

The cost is the same.

(b) $10,000(1 + f)^{20} = 31,617.58$
 $(1 + f)^{20} = 3.1618$
 $20[\log(1 + f)] = \log 3.1628$
 $\log(1 + f) = 0.0250$
 $1 + f = 10^{0.025}$
 $1 + f = 1.05925$
 $f = 5.925\%$

(c) Year 1: Machine A cost = $10,000(1.10) = \$11,000$
Machine B cost = $10,000(1.02) = \$10,200$

Year 2: Machine A cost = $11,000(1.10) = \$12,100$
Machine B cost = $10,200(1.02) = \$10,404$

Year 3: Machine A cost = $12,100(1.02) = \$12,342$
Machine B cost = $10,404(1.10) = \$11,444.40$

Year 4: Machine A cost = $12,342(1.02) = \$12,588.84$
Machine B cost = $11,444.40(1.10) = \$12,588.84$

Machine A will cost more than machine B in all years except years 4, 8, 12, 16, and 20.

14.45 $F = P[(1 + i)(1 + f)(1 + g)]^n$
 $= 300,000[(1 + 0.10)(1 + 0.03)(1 + 0.02)]^3$
 $= 300,000(1.5434)$
 $= \$463,020$

14.46 $i_f = 0.07 + 0.04 + (0.07)(0.04)$
 $= 11.28\%$

$AW_A = -300,000(A/P, 11.28\%, 10) - 900,000$
 $= -300,000(0.17180) - 900,000$
 $= \$-951,540$

$AW_B = -1,200,000(A/P, 11.28\%, 10) - 200,000 - 150,000$
 $= -1,200,000(0.17180) - 200,000 - 150,000$
 $= \$-556,160$

Select Plan B

14.47 Calculate amount needed at 5% inflation rate and then find A using market rate.

$$\begin{aligned} F &= 72,000(1 + 0.05)^3 \\ &= 72,000(1.1576) \\ &= \$83,347 \end{aligned}$$

$$\begin{aligned} A &= 83,347(A/F, 12\%, 3) \\ &= 83,347(0.29635) \\ &= \$24,700 \text{ per year} \end{aligned}$$

14.48 $i_f = 0.22 + 0.05 + (0.22)(0.05)$
 $= 28.1\%$

$$\begin{aligned} A &= 500,000(A/P, 28.1\%, 5) \\ &= 500,000(0.39572) \\ &= \$197,860 \end{aligned}$$

14.49 $i_f = 0.15 + 0.05 + (0.15)(0.05)$
 $= 20.75\%$

$$\begin{aligned} AW_X &= -65,000(A/P, 20.75\%, 5) - 40,000 \\ &= -65,000(0.33991) - 40,000 \\ &= \$-62,094 \end{aligned}$$

$$\begin{aligned} AW_Y &= -90,000(A/P, 20.75\%, 5) - 34,000 + 10,000(A/F, 20.75\%, 5) \\ &= -90,000(0.33991) - 34,000 + 10,000(0.13241) \\ &= \$-63,268 \end{aligned}$$

Therefore, select process X

14.50 $i_f = 0.12 + 0.03 + (0.12)(0.03)$
 $= 15.36\%$

$$\begin{aligned} A &= -3,700,000(A/P, 15.36\%, 5) \\ &= -3,700,000(0.30086) \\ &= \$-1,113,182 \text{ per year} \end{aligned}$$

14.51 $i_f = 0.10 + 0.04 + (0.10)(0.04)$
 $= 14.4\% \text{ per year}$

$$\begin{aligned} A &= -40,000(A/P, 14.4\%, 3) - 24,000 + 6000(A/F, 14.4\%, 3) \\ &= -40,000(0.43363) - 24,000 + 6000(0.28963) \\ &= \$-39,607 \text{ per year} \end{aligned}$$

14.52 $i_f = 0.09 + 0.03 + (0.09)(0.03)$
 $= 12.27\% \text{ per year}$

$$\begin{aligned}
 A &= -180,000(A/P, 12.27\%, 5) - 70,000(P/F, 12.27\%, 3)(A/P, 12.27\%, 5) \\
 &= -180,000(0.27927) - 70,000(0.70666)(0.27927) \\
 &= \$-64,083 \text{ per year}
 \end{aligned}$$

14.53 $i_f = 0.20 + 0.05 + (0.20)(0.05)$
 $= 26\% \text{ per year}$

(a) $CR = A = 2,500,000(A/P, 26\%, 5)$
 $= 2,500,000(0.37950)$
 $= \$948,750 \text{ per year}$

(b) Now the \$2.5 million is a future value

$$\begin{aligned}
 CR = A &= 2,500,000(A/F, 26\%, 5) \\
 &= 2,500,000(0.11950) \\
 &= \$298,750
 \end{aligned}$$

(c) Calculate CR at $i = 20\%$ for $F = \$2.5 \text{ million}$

$$\begin{aligned}
 CR = A &= 2,500,000(A/F, 20\%, 5) \\
 &= 2,500,000(0.13438) \\
 &= \$335,950
 \end{aligned}$$

14.54 Answer is (b)

14.55 Answer is (c)

14.56 Answer is (a)

14.57 $0.16 = i + 0.09 + i(0.09)$
 $1.09i = 0.07$
 $i = 0.064$

Answer is (a)

14.58 $0.06 = i + 0.02 + (i)(0.02)$
 $1.02i = 0.04$
 $i = 3.92$

Answer is (c)

14.59 $\text{Cost} = 40,000/(1 + 0.06)^{10}$
 $= \$22,336$

Answer is (b)

$$\begin{aligned}
 \mathbf{14.60} \quad F &= 1000(F/P, 5\%, 25) \\
 &= 1000(3.3864) \\
 &= \$3386
 \end{aligned}$$

Answer is (b)

$$\begin{aligned}
 \mathbf{14.61} \quad i_f &= 0.06 + 0.04 + (0.06)(0.04) \\
 &= 10.24\%
 \end{aligned}$$

$$\begin{aligned}
 F &= 1000(1 + 0.1024)^{10} \\
 &= \$2650.89
 \end{aligned}$$

Answer is (c)

$$\begin{aligned}
 \mathbf{14.62} \quad i_f &= 0.04 + 0.03 + (0.04)(0.03) \\
 &= 7.12\%
 \end{aligned}$$

$$\begin{aligned}
 P &= 50,000[1/(1 + 0.0712)^6] \\
 &= \$33,094
 \end{aligned}$$

Answer is (c)

14.63 Answer is (d)

14.64 Answer is (b)

Solution to Case Study, Chapter 14

Sometimes, there is not a definitive answer to a case study exercise. Here are example responses.

INFLATION VERSUS STOCK AND BOND INVESTMENTS

1. Stocks: Overall $i^* = 6.6\%$ per year
 Bonds: Overall $i^* = 5.0\%$ per year
2. $i_f = 0.07 + 0.04 + 0.04(0.07) = 11.28\%$
 Stocks: $F_S = 50,000(F/P, 11.28\%, 5) - 1000(F/A, 11.28\%, 5)$
 Bonds: $F_B = 50,000(F/P, 11.28\%, 5) - 2500(F/A, 11.28\%, 5)$
3. Stocks or bonds: $F_S = F_B = 50,000(F/P, 4\%, 5)$
4. Subtract the future value of each payment from the bond face value 5 years from now.
 Both amounts take purchasing power into account.

Stocks: $F_S = 50,000(F/P, 4\%, 5) - 1000(F/A, 4\%, 5)$

Bonds: $F_B = 50,000(F/P, 4\%, 5) - 2500(F/A, 4\%, 5)$

	A	B	C	D	E
1		Stock Investment		Bond Investment	
2	Year	Value, \$	Dividend, \$	Value, \$	Dividend, \$
3	Purchase	50,000	-50,000	50,000	-50,000
4	1	52,500	1,000		2,500
5	2	55,125	1,000		2,500
6	3	57,881	1,000		2,500
7	4	60,775	1,000		2,500
8	5	63,814	1,000		2,500
9	6	67,005	1,000		2,500
10	7	70,355	1,000		2,500
11	8	73,873	1,000		2,500
12	9	77,566	1,000		2,500
13	10	81,445	1,000		2,500
14	11	85,517	1,000		2,500
15	12	89,793	90,793	50,000	52,500
16					
17	#1. Overall i^*		6.6%		5.0%
18	#2. Sell at $i_f = 11.28\%$		\$79,058		\$69,664
19	#3. Sell at buying power		\$60,833		\$60,833
	#4. Sell at buying power				
20	- dividend future value		\$55,416		\$47,292

$$\begin{aligned}
 5. \text{ Stocks: } F &= 50,000(P/F, 11.28\%, 12) - 1,000(F/A, 11.28\%, 12) \\
 &= 50,000(3.60583) - 1000(23.10134) \\
 &= \$157,190
 \end{aligned}$$

$$\begin{aligned}
 \text{Bonds: } P &= 50,000(P/F, 11.28\%, 12) + 2500(P/A, 11.28\%, 12) \\
 &= 50,000(0.27733) + 2500(6.40666) \\
 &= \$29,883
 \end{aligned}$$

(Note: Goal Seek will find the answers, also. Target cells are row 17, the i^* values set to 11.28% and changing cells are C15 for stocks and E3 for bonds.)

Do the answers seem reasonable?

Stocks: Possibly, if the economy and selected corporate stocks do very well.

Bonds: Probably not, the discount required is far more than given when a bond is purchased. This is why, in part, the fixed-income investments are losers when inflation is a sincere factor.

Chapter 15

Cost Estimation

15.1 Ranking most time to least time: detailed estimate, design 60-100% complete, partially designed, order of magnitude, scoping/feasibility.

15.2 Supplies: AOC
Insurance: AOC
Equipment cost: FC
Utility cost: AOC
Installation: FC
Delivery charges: FC
Labor cost: AOC

15.3 Calculate taxes (A), make bids (E), pay bonuses (A), determine profit or loss (A), predict sales (E), set prices (A), evaluate proposals (E), distribute resources (E), plan production (E), and set goals (E)

15.4 Bottom-up: Input = cost estimates; Output = required price
Top-down: Input = competitive price; Output = cost estimates

15.5 Project staff (D), Audit and legal (I), Utilities (I), Rent (I), Raw materials (D), Equipment training (D), Project supplies (D), Labor (D), Administrative staff (I), Miscellaneous office supplies (I)

15.6 License plate (indirect), Drivers license (indirect), Gasoline (direct), Highway toll fee (indirect, since it is usually an option to choose a non-toll route), Oil change (direct), Repairs after collision (indirect), Gasoline tax (direct, since it is a part of the direct cost of gas, Monthly loan payment (indirect), Annual inspection fee (indirect), Garage rental (indirect).

15.7 Conceptual design stage estimates are called *order-of magnitude estimates* and they should be within $\pm 20\%$ of the actual cost.

15.8 $\text{Cost} = 120(58.19) = \6983

15.9 $\text{Cost} = 600(4700) = \$2,820,000$

15.10 $\text{Estimated cost} = 496(6000)$
 $= \$2,976,000$

15.11 $\text{Cost} = 1,350,000(1.70/0.93)$
 $= \$2,467,742$

15.12 $\text{Cost/volume} = 185/[(1\text{ft}^2)(10\text{ ft})] = \18.50 ft^3

15.13 Height = $114/7.55 = 15.1$ feet

15.14 (a) Cost per day = $2(76) + 580 = \$732$ per day
 Cost per cubic yard = $732/160 = \$4.58$ per cubic yard

(b) Cost = $4.58(56) = \$256.20$

15.15 (a) Crew cost per day = $8[25.85 + 28.60 + 5(23.25) + 31.45] = \1617.20

(b) Cost per cubic yard = $1617.20/160 = \$10.11$ per cubic yard

(c) Cost for 250 cubic yards = $10.11(250) = \$2527$

15.16 (a) Cost = $120(21.31 + 5.00) = \$3157$

(b) Cost = $5688 + 6420 + 300 = \$12,408$

(c) Cost = $1667(1.35) + 120(21.31) + 340(7.78) + 5688 + 2240(3.13)$
 $= \$20,152$

15.17 Cost in Texas = $10,500(800)(0.769)$
 $= \$6,459,600$

Cost in California = $10,500(800)(1.085)$
 $= \$9,114,000$

15.18 From Table 15-3, index value in 2001 = 6343; index value in mid-2010 = 8837

$C_t = 30,000,000(8837/6343)$
 $= \$41,795,680$

15.19 To have index value of 100 in year 2000, must divide by 62.21.

(a) New index value in 1995 = $5471/62.21$
 $= 87.9441$

(b) New index value in 2009 = $8570/62.21$
 $= 137.7592$

15.20 (a) First find the compounded percentage increase p between 1995 and 2005.

$7446 = 5471 (F/P, p, 10)$
 $1.36099 = (1+p)^{10}$
 $p = 0.0313$ or 3.13 % per year

$$\begin{aligned}\text{Predicted index value in 2009} &= 7446(F/P, 3.13\%, 4) \\ &= 7446(1+0.0313)^4 \\ &= 8423\end{aligned}$$

$$\begin{aligned}\text{(b) Difference} &= 8570 - 8423 \\ &= 147 \text{ (underestimate)}\end{aligned}$$

15.21 At 1% per month, annual increase $= (1 + 0.01)^{12} - 1 = 12.68\%$

$$\text{Index value} = 100(1.1268) = 112.68$$

15.22 Let f = inflation rate

$$\text{(a) } f = (8837.38 - 8563.35)/8563.35 = 0.032$$

$$\begin{aligned}\text{(b) CCI} &= 8837.38(1 + f)^3 \\ &= 8837.38(1.032)^3 \\ &= 9713.21\end{aligned}$$

15.23 Cost $= 194(1461.3/789.6)$
 $= \$359$

15.24 Value in NY $= 54.3 \text{ million}(12,381.40/4874.06) = \137.94 million

15.25 CCI in 1967 $= 8837.37/8.2272 = 1074.16$

15.26 $96.55 = (\text{Cost in 1913})(2708.51/100)$

$$\text{Cost in 1913} = \$3.56 \text{ per ton}$$

15.27 (a) $40,000 = 21,771(F/P, 2.68\%, n)$
 $40,000 = 21,771(1 + 0.0268)^n$
 $1.83731 = (1.0268)^n$
 $\log 1.83731 = n(\log 1.0268)$
 $n = 23$

$$\begin{aligned}\text{Year} &= 2010 - 23 \\ &= 1987\end{aligned}$$

$$\begin{aligned}\text{(b) Index value} &= 1461.3/(1.0268)^{23} \\ &= 795.4\end{aligned}$$

15.28 The labor cost index probably increased by more than 2%.

15.29 (a) Cost $= 28,000[(125/200)^{0.69}]$

$$= \$20,245$$

$$\begin{aligned} \text{(b) Cost} &= 4100[(1700/900)^{0.67}] \\ &= \$6278 \end{aligned}$$

$$\begin{aligned} \text{15.30 } C_2 &= 13,000(500/4)^{0.37} \\ &= \$77,589 \end{aligned}$$

$$\text{15.31 } C_2 = 58,890(2/0.75)^{0.58} = \$104,017$$

15.32 Use the six-tenths model; exponent = 0.60

$$\begin{aligned} 20,000 &= C_1(300/100)^{0.60} = 1.93318C_1 \\ C_1 &= \$10,346 \end{aligned}$$

$$\begin{aligned} \text{15.33 } 1.52C_1 &= C_1(68/30)^x \\ \log 1.52 &= x \log 2.267 \\ x &= 0.51 \end{aligned}$$

$$\begin{aligned} \text{15.34 Area of 12" pipe} &= \pi(1)^2/4 \\ &= 0.785 \text{ ft}^2 \end{aligned}$$

$$\begin{aligned} \text{Area of 24" pipe} &= \pi(2)^2/4 \\ &= 3.142 \text{ ft}^2 \end{aligned}$$

$$\begin{aligned} 27.23 &= 12.54(3.142/0.785)^x \\ 2.17 &= 4.00^x \\ \log 2.17 &= x \log 4 \\ 0.336 &= 0.602x \\ x &= 0.56 \end{aligned}$$

15.35 Use Equation [15.4] and Table 15-3

$$\begin{aligned} \text{Cost} &= 1.2 \text{ million}[450,000/100,000]^{0.67}](575.8/394.3) \\ &= \$4.8 \text{ million} \end{aligned}$$

$$\begin{aligned} \text{15.36 Cost} &= 3750(2)^{0.89} (1620.6/1104.2) \\ &= \$10,199 \end{aligned}$$

15.37 Let C_1 = cost in 1998; From Table 15-3, M & S index values are 1061.9 in 1998 and 1449.3 in 2008

$$\begin{aligned} 376,900 &= C_1(1449.3/1061.9)(4)^{0.61} \\ C_0 &= \$118,548 \end{aligned}$$

$$\text{15.38 } C_2 = 0.942C_1 = C_1(2)^x$$

$$\log 0.942 = x \log 2$$

$$x = -0.0862$$

$$\mathbf{15.39} \quad C_T = 2.25(1,800,000) = \$4,050,000$$

$$\mathbf{15.40} \quad 1,320,000 = h(225,000)$$

$$h = 5.87$$

$$\mathbf{15.41} \quad C_T = (1 + 1.32 + 0.45)(870,000)$$

$$= \$2,409,900$$

15.42 First find direct cost; then multiply by indirect cost factor:

$$h = 1 + 1.28 + 0.23 = 2.51$$

$$C_T = [243,000(2.51)](1.84)$$

$$= \$1,122,271$$

$$\mathbf{15.43} \quad 2,300,000 = (1 + 1.35 + 0.41)C_E$$

$$C_E = \$833,333$$

$$\mathbf{15.44} \quad C_T = [400,000(1 + 3.1)][1 + 0.38]$$

$$= \$2,263,200$$

$$\mathbf{15.45} \quad (a) \quad h = 1 + 0.30 + 0.30 = 1.60$$

Let x be the indirect cost factor

$$C_T = 430,000 = [250,000 (1.60)] (1 + x)$$

$$(1 + x) = 430,000/[250,000(1.60)]$$

$$= 1.075$$

$$x = 0.075$$

The indirect cost factor used is much lower than 0.40.

$$(b) \quad C_T = 250,000[1.60](1.40)$$

$$= \$560,000$$

$$\mathbf{15.46} \quad \text{Total direct labor hours} = 2000 + 8000 + 5000$$

$$= 15,000 \text{ hours}$$

$$\text{Indirect cost rate/1000 hr} = 36,000/15,000$$

$$= \$2.40$$

$$\begin{aligned}\text{Allocation to Dept A} &= 2000(2.40) \\ &= \$4800\end{aligned}$$

$$\begin{aligned}\text{Allocation to Dept B} &= 8000(2.40) \\ &= \$19,200\end{aligned}$$

$$\begin{aligned}\text{Allocation to Dept C} &= 5000(2.40) \\ &= \$12,000\end{aligned}$$

- 15.47** (a) North: Miles basis; rate = $300,000/350,000 = 0.857$ per mile
 South: Labor basis; rate = $200,000/20,000 = \$10$ per hour
 Midtown: Labor basis; rate = $450,000/64,000 = \$7.03$ per hour

- (b) North: $275,000(0.857) = \$235,675$
 South: $31,000(10) = \$310,000$
 Midtown: $55,500(7.03) = \$390,165$

$$\text{Percent distributed} = (235,675 + 310,000 + 390,165)/1.2 \text{ million} \times 100\% = 78\%$$

- 15.48** Rate for CC100 = $25,000/800 = \$31.25$ per hour
 Rate for CC110 = $50,000/200 = \$250$ per hour
 Rate for CC120 = $75,000/1200 = \$62.50$ per hour
 Rate for CC190 = $100,000/1600 = \$62.50$ per hour

- 15.49** (a) From Equation [15.8], estimated basis level = total costs allocated/rate

Month	Basis Level	Basis
February	$2800/1.40 = 2000$	Space
March	$3400/1.33 = 2556$	Direct labor costs
April	$3500/1.37 = 2555$	Direct labor costs
May	$3600/1.03 = 3495$	Space
June	$6000/0.9 = 6522$	Material costs

- (b) The only way the rate could decrease is by switching the allocation basis from month to month. If a single allocation basis had been used throughout, the rate would have had to increase for each basis. For example, if space had been used for each month, the monthly rates would have been:

Month	Rate
February	$2800/2000 = \$1.40$ per ft ²
March	$3400/2000 = \$1.70$ per ft ²
April	$3500/3500 = \$1.00$ per ft ²
May	$3600/3500 = \$1.03$ per ft ²
June	$6000/3500 = \$1.71$ per ft ²

- 15.50** Determine AW for Make and Buy alternatives. Make has annual indirect costs.

Hand solution:

Make: Indirect cost computation

Dept	Rate (1)	Usage (2)	Annual cost (3) = (1)(2)
X	\$2.40	450,000	\$1.08 million
Y	0.50	850,000	425,000
Z	20.00	4500	90,000
\$/year			\$1,595,000

$$\begin{aligned}
 AW_{\text{make}} &= -3,000,000(A/P, 12\%, 6) + 500,000(A/F, 12\%, 6) - 1,500,000 - 1,595,000 \\
 &= -3,000,000(0.24323) + 500,000(0.12323) - 3,095,000 \\
 &= \$-3,763,075
 \end{aligned}$$

$$\begin{aligned}
 AW_{\text{buy}} &= -3,900,000 - 300,000(A/G, 12\%, 6) \\
 &= -3,900,000 - 300,000(2.1720) \\
 &= \$-4,551,600
 \end{aligned}$$

Select Make alternative

Spreadsheet solution:

	A	B	C	D	E	F
1		MAKE			BUY	
2					Year	Cost
3	Indirect cost computation				1	-3,900,000
4	Dept	Rate	Usage	Indirect cost	2	-4,200,000
5	X	2.40	\$450,000	\$ 1,080,000	3	-4,500,000
6	Y	0.50	\$850,000	\$ 425,000	4	-4,800,000
7	Z	20.00	4500	\$ 90,000	5	-5,100,000
8				\$ 1,595,000	6	-5,400,000
9	PW	-\$15,471,490			PW	-\$18,713,540
10	AW	-\$3,763,064			AW	-\$4,551,614

Select Make alternative

15.51 Total budget = 19 pumps (\$20,000/pump)
= \$380,000

(a) Total Service Trips = 190 + 55 + 38 + 104
= 387

$$\begin{aligned}
 \text{Allocation/Trip} &= 380,000/387 \\
 &= \$981.91
 \end{aligned}$$

Station ID	Service Trips/year	IDC Allocation, \$
------------	--------------------	--------------------

Sylvester	190	$190(981.91) = 186,563$
Laurel	55	$55(981.91) = 54,005$
7 th St	38	$38(981.91) = 37,313$
Spicewood	104	$104(981.91) = 102,119$
		<u>\$380,000</u>

(b) Station ID	Number of pumps	Allocation at \$20,000/pump
Sylvester	5	100,000
Laurel	7	140,000
7 th St	3	60,000
Spicewood	<u>4</u>	<u>80,000</u>
	19	\$380,000

15.52 Determine the rates by basis, then distribute the \$900,000.

	Total usage	Rate
Materials cost	\$51,300	\$17.544/\$
Previous build-time	1395 work-hrs	645.16/work-hr
New build-time	1260 work-hrs	714.29/work-hr

Example allocation for Texas:

Materials cost: $17.544(20,000) = \$350,880$

Previous build time: $645.16(400) = \$258,064$

New build time: $714.29(425) = \$303,573$

	Allocation by each basis		
	Materials cost	Previous build-time	New build-time
TX	\$350,880	\$258,064	\$303,573
OK	222,809	267,741	253,573
KS	326,318	374,193	342,859
Total	\$900,007	\$899,998	\$900,005

15.53 Activities are the department at each hub that lose or damage the baggage.

Cost driver is the number of bags handled, some of which are lost or damaged.

15.54 Total bags handled = 4,835,900

Allocation rate = $667,500/4,835,900 = \$0.13803$ per bag handled

= approximately 13.8¢ per bag checked and handled

	Bags handled	Allocation
DFW	2,490,000	\$343,695
YYZ	1,582,400	218,419
MEX	763,500	105,386

15.55 Compare last year's allocation based on flight traffic with this year's based on

baggage traffic. Significant change took place, especially at MEX.

	Last year; flight basis	This year; baggage basis	Percent change
DFW	\$330,000	\$343,695	+ 4.15%
YYZ	187,500	218,419	+16.5
MEX	150,000	105,386	-29.7

15.56 (a) Rate = \$1 million/16,500 guests = \$60.61 per guest

Charge = number of guests \times rate

	Site			
	A	B	C	D
Guests	3500	4000	8000	1000
Charge, \$	212,135	242,440	484,880	60,610

(b) Guest-nights = (guests) (length of stay)

Total guest-nights = 35,250

Rate = \$1 million/35,250 = \$28.37 per guest-night

	Site			
	A	B	C	D
Guest-nights	10,500	10,000	10,000	4750
Charge, \$	297,885	283,700	283,700	134,757

(c) The actual indirect charge to sites C and D are significantly different by the 2 methods. Another basis could be guest-dollars, that is, total amount of money a guest spends.

15.57 Answer is (c)

15.58 Answer is (b)

15.59 Answer is (d)

15.60 Cost = $2100(200/50)^{0.76}$
= \$6022

Answer is (a)

15.61 Cost = $500,000(5542.16/3378.17)$
= \$820,290

Answer is (c)

15.62 Cost = $3000(500/250)^{0.32}(1449.3/1061.9)$

$$= \$5111.23$$

Answer is (d)

$$\begin{aligned} \mathbf{15.63} \quad 3,000,000 &= 550,000(100,000/6000)^x \\ 5.4545 &= (16.67)^x \\ \log 5.4545 &= x \log(16.67) \\ x &= 0.60 \end{aligned}$$

Answer is (d)

$$\mathbf{15.64} \quad C_T = 2.96(390,000) = \$1,154,400$$

Answer is (c)

$$\begin{aligned} \mathbf{15.65} \quad C_T &= (1 + 1.82 + 0.31)(650,000) \\ &= \$2,034,500 \end{aligned}$$

Answer is (a)

15.66 Answer is (d)

$$\mathbf{15.67} \quad \text{Allocation} = (900 + 1300)(2000) = \$4.4 \text{ million}$$

$$\text{Percent allocated} = 4.4/8.0 \text{ million} = 55\%$$

Answer is (c)

15.68 Answer is (a)

15.69 Answer is (c)

Solution to First Case Study, Chapter 15

There is not always a definitive answer to case study exercises. Here are example responses

INDIRECT COST ANALYSIS OF MEDICAL EQUIPMENT MANUFACTURING COSTS

1. DLH basis

Standard: rate = $\frac{\$1.67 \text{ million}}{187,500 \text{ hrs}} = \$8.91/\text{DLH}$

Premium: rate = $\frac{\$3.33 \text{ million}}{125,000 \text{ hrs}} = \$26.64/\text{DLH}$

(Note: un = unit)

Model	IDC rate	DLH hours	IDC allocation	Direct material	Direct Labor	Total cost	Price, ~1.10 × cost
Standard	\$ 8.91	0.25/un	\$ 2.23/un	2.50/un	\$ 5/un	\$ 9.73/un	\$10.75/un
Premium	26.64	0.50	13.32	3.75	10	27.07	29.75

2.

Activity	Cost Driver	Volume of driver	Total cost/year	ABC IDC rate
Quality	Inspections	20,000	\$800,000	\$40/inspection
Purchasing	Orders	40,000	1,200,000	30/order
Scheduling	Orders	1,000	800,000	800/order
Prod. Set-ups	Set-ups	5,000	1,000,000	200/set-up
Machine Ops	Hours	10,000	1,200,000	120/hour

ABC allocation

Driver	<u>Standard</u>		<u>Premium</u>	
	Volume×rate	IDC allocation	Volume×rate	IDC allocation
Quality	8,000×40	\$320,000	12,000×40	\$480,000
Purchasing	30,000×30	900,000	10,000×30	300,000
Scheduling	400×800	320,000	600×800	480,000
Prod. Set-ups	1,500×200	300,000	3,500×200	700,000
Machine Ops.	7,000×120	840,000	3,000×120	360,000
Total		\$2,680,000		\$2,320,000
Sales volume		750,000		250,000
IDC/unit		\$3.57		\$9.28

Model	Direct material	Direct labor	IDC allocation	Total cost
Standard	2.50	5.00	3.57	\$11.07
Premium	3.75	10.00	9.28	\$23.03

3. Traditional

Model	Profit/unit	Volume	Profit
Standard	$10.75 - 9.73 = \$1.02$	750,000	\$765,000
Premium	$29.75 - 27.07 = \$2.68$	250,000	<u>670,000</u>
Profit			\$1,435,000

ABC

Standard	$10.75 - 11.07 = \$-0.32$	750,000	\$ -240,000
Premium	$29.75 - 23.03 = \$6.72$	250,000	<u>1,680,000</u>
Profit			\$1,440,000

4. Price at Cost + 10%

Model	Cost	Price	Profit/unit	Volume	Profit
Standard	\$11.07	\$12.18	\$1.11	750,000	\$832,500
Premium	23.03	25.33	2.30	250,000	<u>575,000</u>
Profit					\$1,407,000

Profit goes down ~\$33,000

5. a) Prediction about IDC allocation - The manager was right on IDC allocation under ABC, but totally wrong on traditional where the cost is ~ 1/3 and IDC is ~1/6.

Model	Allocation	
	Traditional	ABC
Standard	\$2.23/unit	\$3.57/un
Premium	13.32	9.28

b) Cost versus profit comment – Wrong, if old prices are retained. Under ABC method, the standard model loses \$0.32/unit. Price for standard should go up.

Premium model makes a good profit at current price under ABC ($29.75 - 23.03 = \$6.72/\text{unit}$).

c) Premium require more activities and operations comment

Wrong : Premium model is lower in cost driver volume for purchase orders and machine operations hours, but is higher on set ups and inspections. However, number of set-ups is low (5000 total) and (quality) inspections have a low cost at \$40/inspection.

Overall – Not a correct impression when costs are examined.

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 16
Depreciation Methods

- 16.1** Depreciation increases the company's after-tax cash flow, because depreciation reduces the amount of income taxes a company must pay.
- 16.2** Book value is established on the basis of accepted accounting procedures. Market value is the amount that could be received if the asset is offered for sale on the open market.
- 16.3** Book depreciation is used on internal financial records to reflect current capital investment in the asset. Tax depreciation is used to determine the annual tax-deductible amount. They are not necessarily the same amount.
- 16.4** Unadjusted basis refers to the first cost plus any other depreciable costs that make the asset ready for operation. The adjusted basis means some depreciation has been charged.
- 16.5** MACRS has set n values for depreciation by property class. These are commonly different, usually shorter, than the anticipated useful life of an asset used in the economic evaluation.
- 16.6** Quoting Publication 946, 2010 version:
- (a) "Depreciation is an annual income tax deduction that allows you to recover the cost or other basis of certain property over the time you use the property. It is an allowance for the wear and tear, deterioration, or obsolescence of the property."
 - (b) "An estimated value of property at the end of its useful life. Not used under MACRS."
 - (c) General Depreciation System (GDS) and Alternative Depreciation System (ADS). The recovery period and method of depreciation are the primary differences.
 - (d) The following cannot be MACRS depreciated: intangible property; films and video tapes and recordings; certain property acquired in a nontaxable transfer; and property placed into service before 1987.
 - (e) Depreciation *starts* when property is placed in service, when it is ready and available for a specific use, whether in a business activity, an income-producing activity, a tax-exempt activity, or a personal activity. Even if not using the property, it is in service when it is ready and available for its specific use.

Depreciating *stops* when property is retired from service, even if its cost is not fully recovered .

- (f) A taxpayer can elect to recover all or part of the cost of certain qualifying property, up to a limit, by deducting it in the year the property is placed in service. The taxpayer can elect the Section 179 deduction instead of recovering the cost through depreciation deductions.

16.7 $B = 580,000 + 4300 + 6400 = \$590,700$

$n = 15$ years

$S = 0$ (MACRS does not use an estimated salvage value)

16.8 (a) $B = \$350,000 + 50,000 = \$400,000$

$n = 7$ years

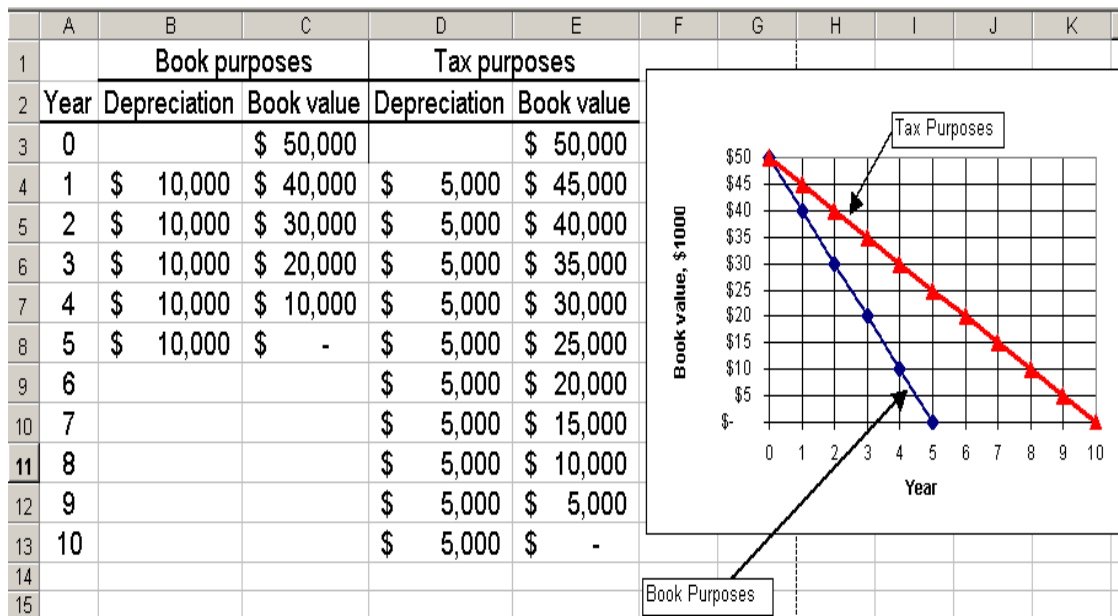
$S = 0.1(350,000) = \$35,000$

(b) Remaining life = 3 years

Market value = \$45,000

Book Value = $\$400,000(1 - 0.65) = \$140,000$

16.9 Write the cell equations to determine depreciation of \$10,000 per year for book purpose and \$5000 per year for tax purposes. Develop the scatter chart to plot book values.



16.10 $d_t = 1/n = 1/8 = 0.125$ or 12.5% per year

16.11 (a) $D_3 = (40,000 - 10,000)/10 = \3000

(b) PW of $D_3 = 3000(P/F, 11\%, 3) = \2193.60

(c) $BV_3 = 40,000 - 3(3000) = \$31,000$

16.12 (a) $D_3 = 26,000$

$$BV_3 = 62,000 = B - 3(26,000)$$

$$B = \$140,000$$

(b) $26,000 = (140,000 - S)/5$

$$S = \$10,000$$

16.13 (a) If the machine will have $BV = 0$ at the end of 5 years, the SL book depreciation charge for each of the last 2 years will have to be

$$D_t = 30,000/2 = \$15,000 \text{ per year}$$

(b) $15,000 = (B - 0)/5$

$$B = \$75,000$$

16.14 $BV_5 = 200,000 - 5 * SLN(200000, 10000, 7)$

Answer is \$64,285.71

16.15 Use the spreadsheet below.

(a) In 2012, $BV_4 = \$450,000$

(b) Loss = BV_4 - selling price = $450,000 - 175,000 = \$275,000$

(c) Two more years when $BV_6 = \$300,000$

	A	B	C	D
1	Calendar	Recovery	Straight line	
2	Year	Year	Depreciation, \$	Book Value, \$
3	2008	0		750,000
4	2009	1	75,000	675,000
5	2010	2	75,000	600,000
6	2011	3	75,000	525,000
7	2012	4	75,000	450,000
8	2013	5	75,000	375,000
9	2014	6	75,000	300,000
10	2015	7	75,000	225,000
11	2016	8	75,000	150,000
12	2017	9	75,000	75,000
13	2018	10	75,000	0

16.16 (a) $B = \$50,000$, $n = 4$, $S = 0$, $d = 0.25$

$$D_t = 50,000/4 = \$12,500 \text{ per year}$$

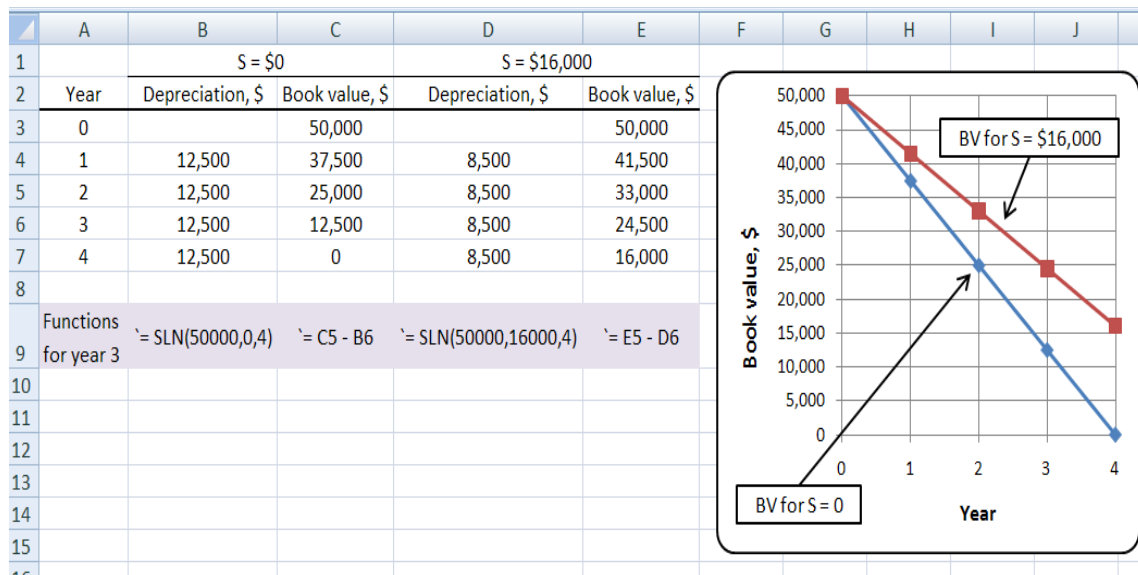
Year, t	D_t	Accumulated depreciation	BV_t
0	---	---	\$50,000
1	\$12,500	\$12,500	37,500
2	12,500	25,000	25,000
3	12,500	37,500	12,500
4	12,500	50,000	0

(b) $S = \$16,000$; $d = 0.25$; $B - S = \$34,000$

$$D_t = (50,000 - 16,000) / 4 = \$8500 \text{ per year}$$

Year, t	D_t	Accumulated depreciation	BV_t
0	---	---	\$50,000
1	\$8,500	\$8,500	41,500
2	8,500	17,000	33,000
3	8,500	25,500	24,500
4	8,500	34,000	16,000

(c) Spreadsheet chart showing $S = 0$ and $S = \$16,000$ book values are the same as above.



16.17 Develop difference relations (US minus EU) for (a) depreciation and (b) book value in year 5 with the SLN function.

	A	B	C	D	E	F	G	H
1		US - EU differences						
2	(a) D_5				\$120,000			
3	Function	$= \text{SLN}(2000000, 0.2 * 2000000, 5) - \text{SLN}(2000000, 0.2 * 2000000, 8)$						
4	(b) BV_5				\$600,000			
5	Function	$= 5 * \text{SLN}(2000000, 0.2 * 2000000, 5) - 5 * \text{SLN}(2000000, 0.2 * 2000000, 8)$						

16.18 d is decimal amount of BV removed each year.

d_{\max} is maximum legal rate of depreciation for each year; $2/n$ for DDB.

d_t is actual depreciation rate charged using a particular depreciation model; for DB model, it is $d(1-d)^{t-1}$.

16.19 (a) $d = 2/15 = 0.133$

$$D_2 = 0.133(182,000)(1 - 0.133)^1 \\ = \$20,987$$

$$D_{10} = 0.133(182,000)(1 - 0.133)^9 \\ = \$6700$$

$$(b) BV_2 = 182,000(1 - 0.133)^2 \\ = \$136,807$$

$$BV_{10} = 182,000(1 - 0.133)^{10} \\ = \$43,678$$

16.20 (a) D for all years $= (600,000 - 0)/30 = \$20,000$

(b) $d = 2/30 = 0.067$

$$D_4 = (0.067)(600,000)(1 - 0.067)^3 \\ = \$32,649$$

$$D_{10} = (0.067)(600,000)(1 - 0.067)^9 \\ = \$21,536$$

$$D_{25} = (0.067)(600,000)(1 - 0.067)^{24} \\ = \$7610$$

(c) $\text{Implied } S = 600,000(1 - 0.067)^{30}$
 $= \$74,920$

(d) Hand solution used 3-decimal accuracy and spreadsheet accuracy has more decimal places. The round-off errors are noticeable. For example, implied $S = \$74,920$ (hand) and $\$75,728$ (spreadsheet), an $\$808$ or $1+\%$ difference.

	A	B	C	D	E
1		Straight Line		Double Declining	
2	Year	Depreciation	Book value	Depreciation	Book value
3	0		\$600,000		\$600,000
4	1	\$20,000	580,000	\$40,000	560,000
5	2	20,000	560,000	37,333	522,667
6	3	20,000	540,000	34,844	487,822
7	4	20,000	520,000	32,521	455,301
8	5	20,000	500,000	30,353	424,947
9	6	20,000	480,000	28,330	396,618
10	7	20,000	460,000	26,441	370,176
11	8	20,000	440,000	24,678	345,498
12	9	20,000	420,000	23,033	322,465
13	10	20,000	400,000	21,498	300,967
14	11	20,000	380,000	20,064	280,903
15	12	20,000	360,000	18,727	262,176
16	13	20,000	340,000	17,478	244,697
17	14	20,000	320,000	16,313	228,384
18	15	20,000	300,000	15,226	213,159
19	16	20,000	280,000	14,211	198,948
20	17	20,000	260,000	13,263	185,685
21	18	20,000	240,000	12,379	173,306
22	19	20,000	220,000	11,554	161,752
23	20	20,000	200,000	10,783	150,969
24	21	20,000	180,000	10,065	140,904
25	22	20,000	160,000	9,394	131,510
26	23	20,000	140,000	8,767	122,743
27	24	20,000	120,000	8,183	114,560
28	25	20,000	100,000	7,637	106,923
29	26	20,000	80,000	7,128	99,795
30	27	20,000	60,000	6,653	93,142
31	28	20,000	40,000	6,209	86,932
32	29	20,000	20,000	5,795	81,137
33	30	20,000	0	5,409	75,728

16.21 $D = 2/5 = 0.40$
 $BV_3 = 30,000(1 - 0.40)^3$
 $= \$6480$

Difference = $6480 - 5000 = \$1480$

16.22 (a) DDB: $d = 2/12 = 0.167$
 $BV_{12} = B(1-d)^{12} = 180,000(1-0.167)^{12}$
 $= \$20,092$

150% DB: $d = 1.5/12 = 0.125$
 $BV_{12} = 180,000(1-0.125)^{12}$
 $= \$36,255$

(b) $S = \$30,000$ is between the two implied salvages.

(c) DDB: writes off *more* since all \$150,000 is depreciated

150% DB: writes off *less* since it will stop at $BV_{12} = \$36,255$

16.23 (a) SL: $BV_{10} = \$10,000$ by definition

DDB: Determine if the implied $S < \$10,000$ with $d = 2/7 = 0.2857$

$$BV_{10} = BV_7 = 100,000(0.7143)^7 \\ = \$9488$$

Both salvage values are less than the market value of \$12,500

(b) SL: $D_{10} = (100,000 - 12,500)/10 = \8750 per year

DDB: $D_{10} = 0$, since $n = 7$ years

Spreadsheet solution for both parts follows.

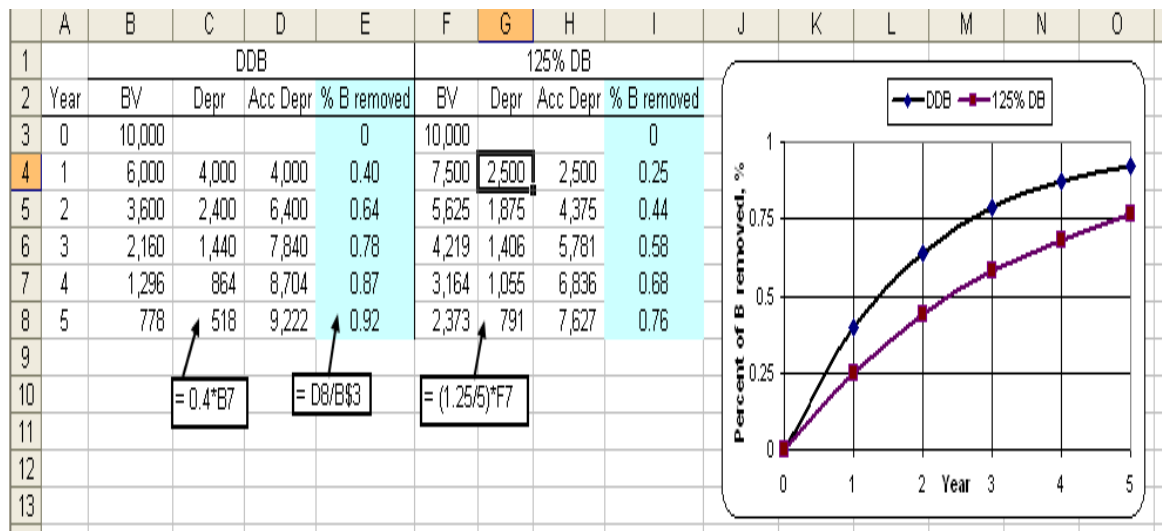
	A	B	C	D	E	F	G	H	I	J
1		Part (a)			Part (b)					
2	Year	SL Depr	DDB Depr	DDB BV	SL Depr	DDB Depr	DDB BV			
3	0			100,000			100,000			
4	1	9,000	28,571	71,429	8,750	28,571	71,429			
5	2	9,000	20,408	51,020	8,750	20,408	51,020			
6	3	9,000	14,577	36,443	8,750	14,577	36,443			
7	4	9,000	10,412	26,031	8,750	10,412	26,031			
8	5	9,000	7,437	18,593	8,750	7,437	18,593			
9	6	9,000	5,312	13,281	8,750	5,312	13,281	= DDB(100000,12500,7,A10,2)		
10	7	9,000	3,795	9,486	8,750	781	12,500			
11	8	9,000	0	9,486	8,750	0	12,500			
12	9	9,000	0	9,486	8,750	0	12,500			
13	10	9,000	0	9,486	8,750	0	12,500			
14		90,000	90,514		87,500	87,500				
15										
16		= SLN(100000,10000,10)			= DDB(100000,0,7,A10,2)			= SLN(100000,12500,10)		
17										
18										

16.24 Select any first cost value to use for B. The spreadsheet below uses \$10,000.

DDB: $d = 2/5 = 0.40$

125% DB: $d = 1.25/5 = 0.25$

DDB accumulates percentage faster and more in total than 125% DB.



16.25 SL is the classic non-accelerated method. Anything that has a BV curve below the SL BV curve is considered accelerated depreciation. MACRS is accelerated compared to SL depreciation because more of the first cost is written off in the early years of the recovery period.

16.26 A primary intent was economic growth through capital investment and the tax advantages that accelerated depreciation offers to industry.

16.27 (a) $D_2 = 80,000(0.32) = \$25,600$

(b) $BV_2 = 80,000 - 80,000(0.20 + 0.32)$
 $= 80,000 - 41,600$
 $= \$38,400$

16.28 (a) From MACRS depreciation rate table, $d_2 = 0.32$

$$B = 24,320 / 0.32 = \$76,000$$

(b) From MACRS depreciation rate table, d_1 for year 1 = 0.20

$$D_1 = 76,000(0.20) = \$15,200$$

(c) The function is $= VDB(76000, 0, 5, MAX(0, t-1.5), MIN(5, t-0.5), 2)$

	A	B	C	D	E	F	G
1	Year t	MACRS D_t	VDB function for MACRS depreciation in year t				MACRS BV_t
2	0						76,000
3	1	\$15,200	`= VDB(76000,0,5,MAX(0,\$A3-1.5), MIN(5,\$A3-0.5),2)				60,800
4	2	\$24,320	`= VDB(76000,0,5,MAX(0,\$A4-1.5), MIN(5,\$A4-0.5),2)				36,480
5	3	\$14,592	`= VDB(76000,0,5,MAX(0,\$A5-1.5), MIN(5,\$A5-0.5),2)				21,888
6	4	\$8,755	`= VDB(76000,0,5,MAX(0,\$A6-1.5), MIN(5,\$A6-0.5),2)				13,133
7	5	\$8,755	`= VDB(76000,0,5,MAX(0,\$A7-1.5), MIN(5,\$A7-0.5),2)				4,378
8	6	\$4,378	`= VDB(76000,0,5,MAX(0,\$A8-1.5), MIN(5,\$A8-0.5),2)				0

16.29 Straight line: $D = [80,000 - 0.25(80,000)]/5$
 $= \$12,000$ per year

$$BV_4 = 80,000 - 4(12,000) = \$32,000$$

$$\begin{aligned} \text{MACRS: } BV_4 &= 80,000 - 80,000(0.20 + 0.32 + 0.192 + 0.1152) \\ &= 80,000 - 66,176 \\ &= \$13,824 \end{aligned}$$

$$\text{Difference} = 32,000 - 13,824 = \$18,176$$

16.30 MACRS: $BV_3 = 300,000 - 300,000(0.20 + 0.32 + 0.192)$
 $= 300,000 - 213,600$
 $= \$86,400$

$$\text{DDB: } d = 2/5 = 0.40$$

$$\begin{aligned} BV_3 &= 300,000(1 - 0.4)^3 \\ &= \$64,800 \end{aligned}$$

DDB provides a faster write-off after 3 years by $86,400 - 64,800 = \$21,600$

16.31 Recovery period is 7 years from Table 16-4. Book values are close for both ways.

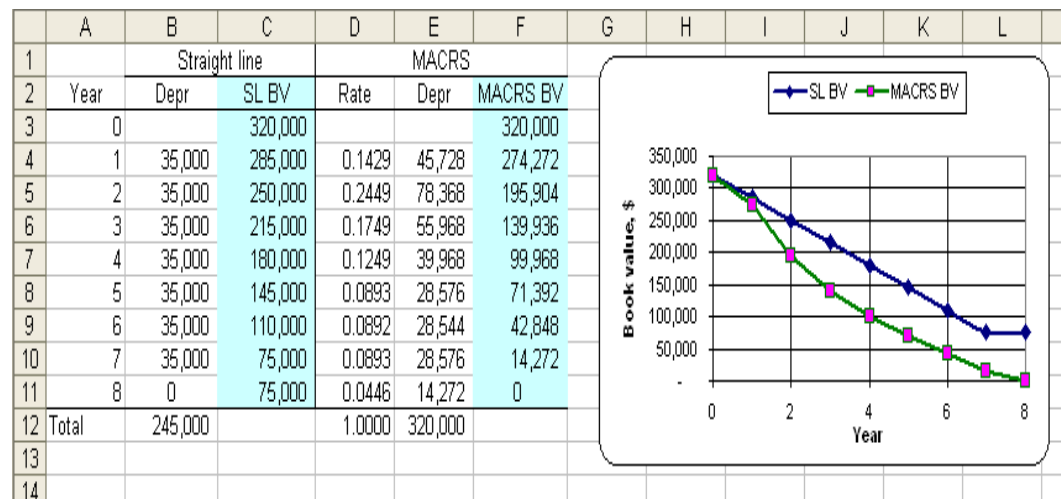
$$D_t = \text{rate}(1,200,000) \quad \text{and} \quad BV_t = BV_{t-1} - D_t$$

	A	B	C	D	E	F
1		MACRS via VDB function		MACRS via tabulated rates		
2	Year	Depreciation	Book value	Rate	Depreciation	Book value
3	0		1,200,000			1,200,000
4	1	171,429	1,028,571	0.1429	171,480	1,028,520
5	2	293,878	734,694	0.2449	293,880	734,640
6	3	209,913	524,781	0.1749	209,880	524,760
7	4	149,938	374,844	0.1249	149,880	374,880
8	5	107,098	267,746	0.0893	107,160	267,720
9	6	107,098	160,647	0.0892	107,040	160,680
10	7	107,098	53,549	0.0893	107,160	53,520
11	8	53,549	0	0.0446	53,520	0
12				1.0000		

- 16.32 (a) SL: $D_t = (320,000 - 75,000)/7 = \$35,000$ per year
MACRS: $D_t = \text{rate}(320,000)$

	Straight line		MACRS		
Year	Depr	BV	Rate	Depr	BV
0		320,000			320,000
1	35,000	285,000	0.1429	45,728	274,272
2	35,000	250,000	0.2449	78,368	195,904
3	35,000	215,000	0.1749	55,968	139,936
4	35,000	180,000	0.1249	39,968	99,968
5	35,000	145,000	0.0893	28,576	71,392
6	35,000	110,000	0.0892	28,544	42,848
7	35,000	75,000	0.0893	28,576	14,272
8	0	75,000	0.0446	14,272	0

Spreadsheet solution with BV plots follow.



- (b) MACRS neglects the salvage value; it always depreciates to zero.

16.33 (a) MACRS: rate for year 3 is 0.1440; sum of rates for 3 years is 0.4240

$$D_3 = 0.1440(800,000) = \$115,200$$

$$BV_3 = 800,000 - 0.4240(800,000) = \$460,800$$

(b) DDB: $d = 2/15 = 0.13333$

$$D_3 = 0.13333(800,000)(1-0.13333)^2 = \$80,117$$

$$BV_3 = 800,000(1-0.13333)^3 = \$520,776$$

(c) ADS SL: $d = 1/15 = 0.06666$ years 2 through 15; $\frac{1}{2}$ that for years 1 and 16.

$$D_3 = 0.06666(800,000 - 150,000) = \$43,329$$

$$BV_3 = 800,000 - 2.5(43,329) = \$691,678$$

Spreadsheet solution for all parts follows. The relations used to determine the values (row 50 are indicated first (row 3).

	A	B	C	D	E	F
1	MACRS		DDB		SL	
2	Depr	BV	Depr	BV	Depr	BV
3	$= 0.144 * 800000 = 800000 - 800000 * (0.1 + 0.18 + 0.144) = DDB(800000, 150000, 15, 3, 2) = 800000 * (1 - 2/15)^3 = (800000 - 150000) / 15 = 800000 - 2.5 * E\3					
4						
5	115200	460800	80118	520770	43333	691666

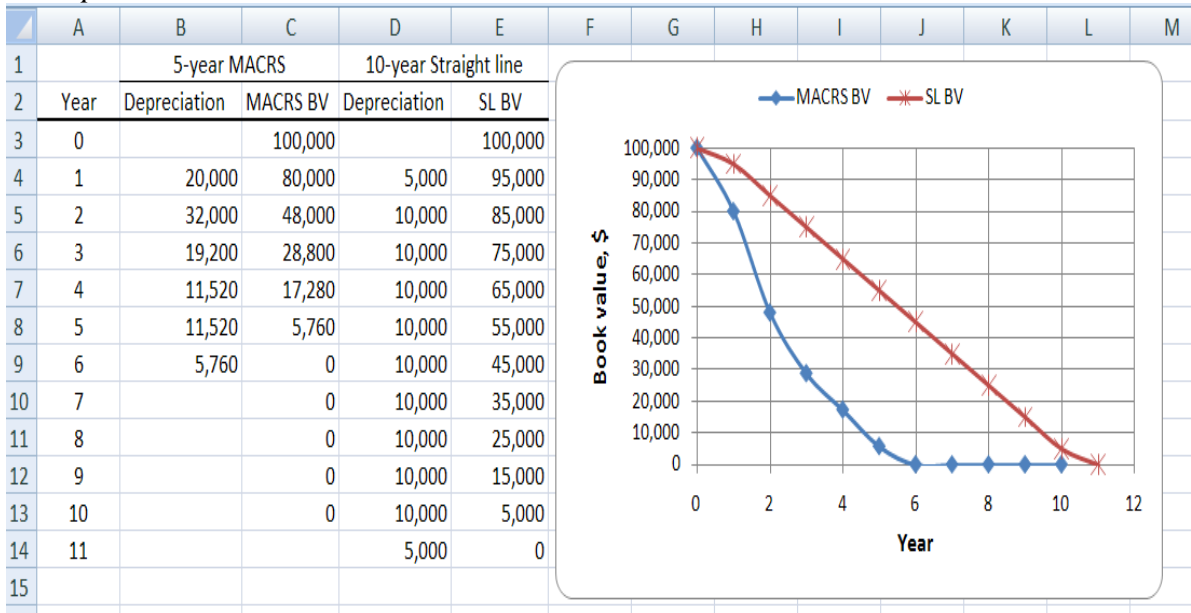
16.34 (a) MACRS: $n = 5$, $B = \$100,000$

SL: $n = 10$, $d = 0.05$ in years 1 and 11 and $d = 0.1$ in all others

Hand solution

Year	MACRS			SL		
	d	Depr	BV	d	Depr	BV
0	-	-	\$100,000	-	-	\$100,000
1	0.2000	\$20,000	80,000	0.05	\$ 5,000	95,000
2	0.3200	32,000	48,000	0.10	10,000	85,000
3	0.1920	19,200	28,800	0.10	10,000	75,000
4	0.1152	11,520	17,280	0.10	10,000	65,000
5	0.1152	11,520	5760	0.10	10,000	55,000
6	0.0576	5760	0	0.10	10,000	45,000
7	-----	-----	0	0.10	10,000	35,000
8	-----	-----	0	0.10	10,000	25,000
9	-----	-----	0	0.10	10,000	15,000
10	-----	-----	0	0.10	10,000	5000
11	-----	-----	0	0.05	5000	0

Spreadsheet solution

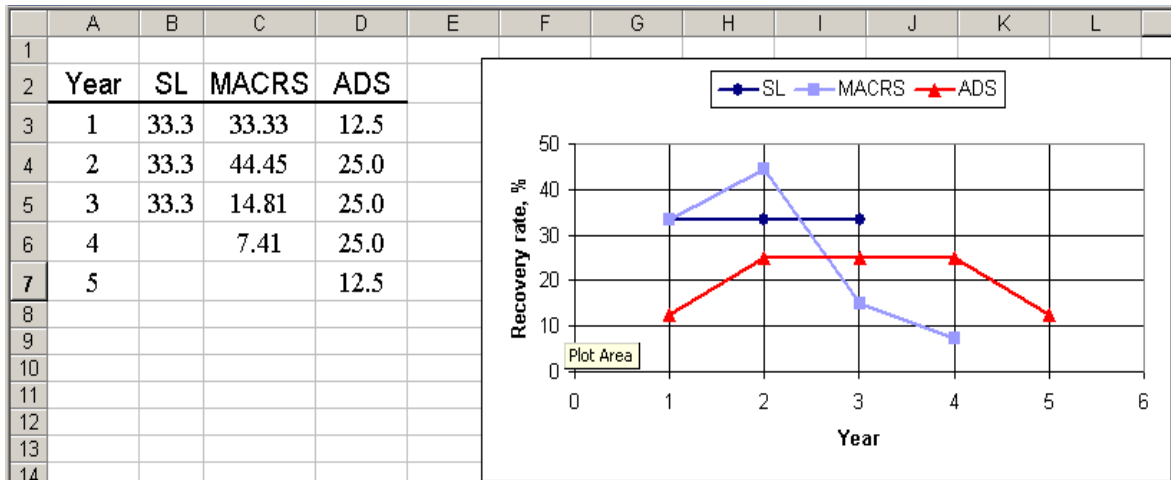


- (b) MACRS: sum d values for 3 years: $0.20 + 0.32 + 0.192 = 0.712$ (71.2%)
 SL: sum the d values for 3 years: $0.05 + 0.1 + 0.1 = 0.25$ (25%)

SL depreciates much slower early in the recovery period.

16.35 ADS recovery rates are $d = \frac{1}{4} = 0.25$ except for years 1 and 5, which are 50% of this.

Year	d values (%)		
	SL	MACRS	ADS MACRS
1	33.3	33.33	12.5
2	33.3	44.45	25.0
3	33.3	14.81	25.0
4	0	7.41	25.0
5			12.5



16.36 (a) $CD_t = 7,000,000/4,000,000 = \1.75 per ton

Cost Allowance - Year 1: $1.75(21,000) = \$36,750$
Year 2: $1.75(18,000) = \$31,500$
Year 3: $1.75(20,000) = \$35,000$

(b) Percent of purchase = $103,250/7,000,000 = 0.015$ (1.5%)

16.37 (a) There is no depletion deduction in year 2 because no raw materials will be harvested until year 3.

(b) Timber cannot be depleted using the percentage depletion method.

16.38 (a) $\text{Income} = 50,000(6) + 80,000(9) = \$1,020,000$

Depletion charge = $1,020,000(0.05) = \$51,000$

(b) No, only 50% of taxable income, or \$50,000, is allowed.

16.39 $CD_t = 9,000,000/280,000 = \32.14 per ton

Depletion year 1: $20,000(32.14) = \$642,800$

Depletion year 2: $30,000(32.14) = \$964,200$

16.40 Percentage depletion for gold is 15% of gross income, provided it does not exceed 50% of taxable income.

<u>Year</u>	<u>Gross*</u> <u>Income</u>	<u>PDA</u> <u>at 15%</u>	<u>50%</u> <u>of TI</u>	<u>Allowed</u> <u>depletion</u>
1	2,007,000	301,050	750,000	301,050
2	6,715,500	1,007,325	1,000,000	1,000,000
3	2,865,800	429,870	400,000	400,000

*Ounces \times \$/ounce

16.41 (a) Cost depletion: $CD_t = \$3.2/2.5 \text{ million} = \1.28 per ton

Percentage depletion: $PD = 5\%$ of gross income

Year	Tonnage for cost depletion	Per-ton gross income	Gross income for percentage depletion
1	60,000	\$30	\$ 1,800,000
2	50,000	25	1,250,000
3	58,000	35	2,030,000
4	60,000	35	2,100,000
5	65,000	40	2,600,000

Year	CDA at \$1.28 × tons	PDA at 5% of GI	Selected
1	\$76,800	\$90,000	PDA
2	64,000	62,500	CDA
3	74,240	101,500	PDA
4	76,800	105,000	PDA
5	83,200	130,000	PDA

(b) Total depletion is \$490,500

$$\% \text{ written off} = 490,500 / 3.2 \text{ million} = 0.1533 \quad (15.33\%)$$

(c) Undepleted investment after 3 years:

$$3.2 \text{ million} - (90,000 + 64,000 + 101,500) = \$2,944,500$$

New cost depletion factor for years 4 and after:

$$\begin{aligned} \text{CD}_t &= \$2.9445 \text{ million} / 1.5 \text{ million tons} \\ &= \$1.963 \text{ per ton} \end{aligned}$$

Cost depletion for years 4 and 5:

$$\begin{aligned} \text{Year 4: } &60,000(1.963) = \$117,780 \quad (> \text{PDA}) \\ \text{Year 5: } &65,000(1.963) = \$127,595 \quad (< \text{PDA}) \end{aligned}$$

Percentage depletion amounts are the same: \$105,000 and \$130,000

Conclusion: Select CDA for year 4 and PDA in year 5

$$\% \text{ written off} = \$503,280 / 3.2 \text{ million} = 0.1573 \quad (15.73\%)$$

16.42 Answer is (b)

16.43 Answer is (c)

$$\begin{aligned} \mathbf{16.44} \quad D &= (20,000 - 2000)/5 \\ &= \$3600 \text{ per year} \end{aligned}$$

Answer is (b)

$$\begin{aligned} \mathbf{16.45} \quad D_3 &= 40,000(0.144) \\ &= \$5760 \end{aligned}$$

Answer is (a)

$$\begin{aligned} \mathbf{16.46} \quad \text{Depl} &= 10,000(150)(0.10) \\ &= \$150,000 \end{aligned}$$

Answer is (d)

$$\begin{aligned} \mathbf{16.47} \quad 3000 &= (20,000 - S) / 5 \\ S &= \$5000 \end{aligned}$$

Answer is (c)

16.48 Salvage value does not enter in the calculation of depreciation in the DDB method.

Answer is (a)

$$\mathbf{16.49} \quad \text{BV} = 100,000 - 100,000(0.10 + 0.18 + 0.144 + 0.1152) = \$46,080$$

Answer is (d)

$$\begin{aligned} \mathbf{16.50} \quad 33,025 &= B(0.192) \\ B &= 172,005 \end{aligned}$$

Answer is (b)

$$\mathbf{16.51} \quad \text{CD}_t = (70,000 - 20,000)/25,000 = \$2.00 \text{ per tree}$$

$$\text{Cost depletion, year 1: } 2.00(5000) = \$10,000$$

Answer is (c)

$$\begin{aligned} \mathbf{16.52} \quad \text{Total depreciation} &= \text{first cost} - \text{BV after 3 years} \\ &= 50,000 - 21,850 = \$28,150 \end{aligned}$$

Answer is (d)

16.53 Answer is (b)

16.54 Answer is (c)

Chapter 16 Appendix

16A.1 The SUM = 36; use SYD rates for (B - S) = €10,000

t	d _t	D _t , €	BV _t , €
1	8/36	2,222.22	9777.78
2	7/36	1,944.44	7833.33
3	6/36	1,666.67	6166.67
4	5/36	1,388.89	4777.78
5	4/36	1,111.11	3666.67
6	3/36	833.33	2833.33
7	2/36	555.56	2277.78
8	1/36	277.78	2000.00

16A.2 (a) B = \$150,000; n = 10; S = \$15,000 and SUM = 55.

$$D_2 = \frac{10 - 2 + 1}{55} (150,000 - 15,000) = \$22,091$$

$$BV_2 = 150,000 - \left[\frac{2(10 - 1 + 0.5)}{55} \right] (150,000 - 15,000) = \$103,364$$

$$D_7 = \frac{10 - 7 + 1}{55} (150,000 - 15,000) = \$9,818$$

$$BV_7 = 150,000 - \left[\frac{7(10 - 3.5 + 0.5)}{55} \right] (150,000 - 15,000) = \$29,727$$

(b)

	A	B	C	D	E	F	G
1	Basis =	\$150,000	Salvage at 10% =	\$15,000			
2							
3	Year	Depreciation	Book value	=SYD(150000,15000,10,\$A5)			
4	0		\$150,000				
5	1	\$24,545	\$125,455				
6	2	\$22,091	\$103,364				
7	3	\$19,636	\$83,727				
8	4	\$17,182	\$66,545				
9	5	\$14,727	\$51,818				
10	6	\$12,273	\$39,545				
11	7	\$9,818	\$29,727				
12	8	\$7,364	\$22,364				
13	9	\$4,909	\$17,455				
14	10	\$2,455	\$15,000				

16A.3 $B = \$12,000$; $n = 6$ and $S = 0.15(12,000) = \$1,800$

(a) Use Equation. [16A.2] and $S = 21$.

$$BV_3 = 12,000 - \left[\frac{3(6 - 1.5 + 0.5)}{21} \right] (12,000 - 1800) = \$4714$$

(b) By Eq. [16A.3] and $t = 4$:

$$d_4 = \frac{6 - 4 + 1}{21} = 3/21 = 1/7$$

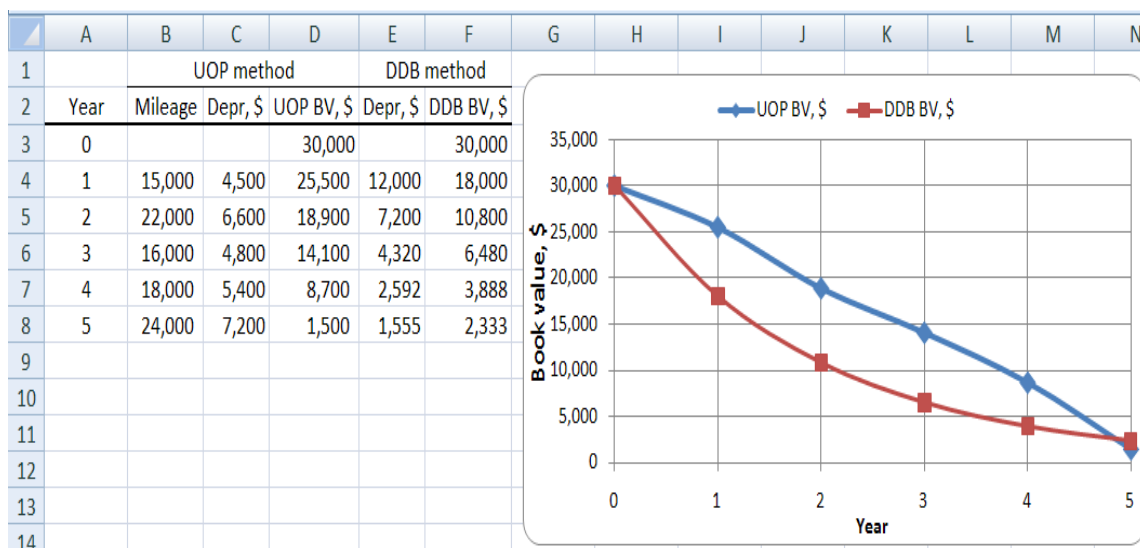
$$\begin{aligned} D_4 &= d_4(B - S) \\ &= (3/21)(12,000 - 1800) \\ &= \$1457 \end{aligned}$$

16A.4 $D_t = (\text{tests per year } t/10,000)(70,000)$

Year t	Number of tests	D_t , \$	BV_t , \$
1	3810	26,670	43,330
2	2720	19,040	24,290
3	5390	24,290*	0

* $D_3 = 5390/10,000(70,000) = \$37,730$ is too large; only the remaining $BV = \$24,290$ can be charged in year 3.

16A.5 Spreadsheet solution is shown using DDB function and Equation [16A.4] for UOP. DDB method does depreciate faster, but UOP, in this case, did depreciate more of the first cost.



16A.6 $B = \$45,000$ $n = 5$ $S = \$3,000$ $i = 18\%$

Compute the D_t for each method and select the larger value to maximize PW_D .

For DDB, $d = 2/5 = 0.4$. By Equation [16A.6], $BV_5 = 45,000(1 - 0.4)^5 = 3,499 > 3,000$

Switching is advisable. Remember to consider $S = \$3,000$ in Equation [16A.8].

t	DDB Method		Switching to SL method	Larger Depreciation
	Eq. [16A.7]	BV	Eq. [16A.8]	
0		\$45,000		
1	\$18,000	27,000	\$8,400	\$18,000 (DDB)
2	10,800	16,200	6,000	10,800 (DDB)
3	6,480	9,720	4,400	6,480 (DDB)
4	3,888	5,832	3,360	3,888 (DDB)
5	2,333	3,499*	2,832	2,832 (SL)

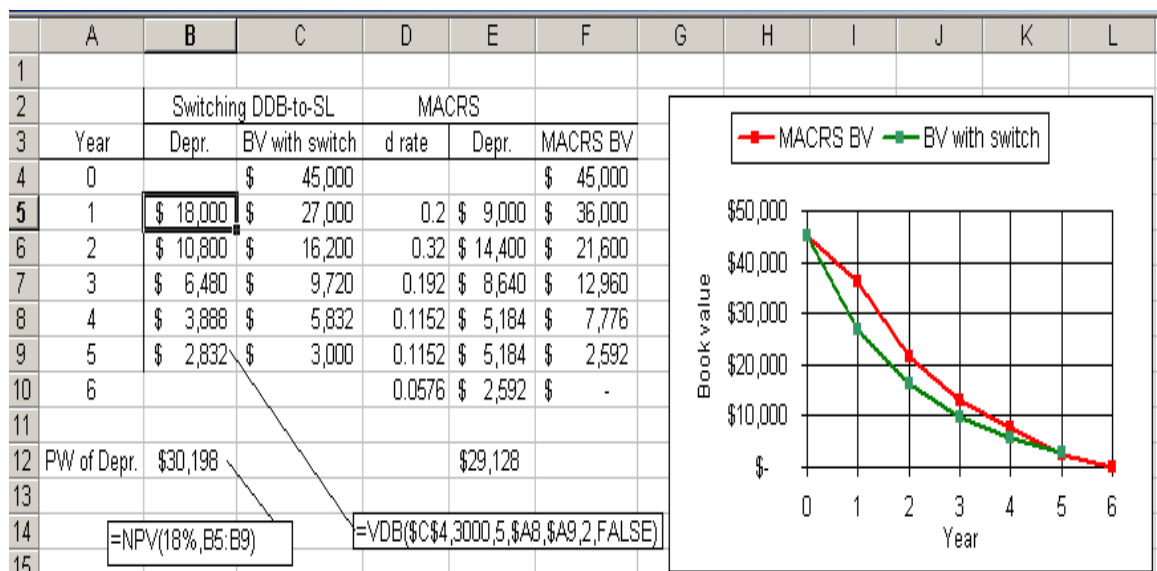
* BV_5 will be \$3000 exactly when SL depreciation of \$2832 is applied in year 5.

$$BV_5 = 5832 - 2832 = \$3000$$

The switch to SL occurs in year 5 and the PW of depreciation is:

$$PW_D = 18,000(P/F, 18\%, 1) + \dots + 2,832(P/F, 18\%, 5) = \$30,198$$

16A.7 Develop a spreadsheet for the DDB-to-SL switch using the VDB function (column B) and MACRS rates or VDB function, plus PW_D for both methods.



Were switching allowed in the US, it would give only a slightly higher $PW_D = \$30,198$ compared to MACRS $PW_D = \$29,128$.

16A.8 175% DB: $d = 1.75/10 = 0.175$ for $t = 1$ to 5

$$BV_t = 110,000(0.825)^t$$

SL: $D_t = (BV_5 - 10,000)/5 = (42,040 - 10,000)/5 = \6408 for $t = 6$ to 10

$$BV = BV_5 - t(6408)$$

$PW_D = \$64,210$ from Column D using the NPV function.

	A	B	C	D
1				
2		175% DB	SL	
3	Year	Depreciation	Depreciation	Book value
4	0			\$110,000
5	1	\$19,250	0	\$90,750
6	2	\$15,881	0	\$74,869
7	3	\$13,102	0	\$61,767
8	4	\$10,809	0	\$50,958
9	5	\$8,918	0	\$42,040
10	6		\$6,408	\$35,632
11	7		\$6,408	\$29,224
12	8		\$6,408	\$22,816
13	9		\$6,408	\$16,408
14	10		\$6,408	\$10,000
15				
16		PW value of depreciation =		\$64,210

$$= \text{NPV}(12\%, B5:B9) + \text{NPV}(12\%, C5:C14)$$

16A.9 (a) Use Equation [16A.6] for DDB with $d = 2/25 = 0.08$

$$BV_{25} = 155,000(1 - 0.08)^{25} = \$19,276.46 < \$50,000$$

No, the switch should not be made

(b) $155,000(1-d)^{25} > 50,000$

$$1 - d > [50,000/155,000]^{1/25}$$

$$1 - d > (0.3226)^{0.04} = 0.95575$$

$$d < 1 - 0.95575 = 0.04425$$

If $d < 0.04425$ the switch is advantageous. This is approximately 50% of the current DDB rate of 0.08. The SL rate would be $d = 1/25 = 0.04$

16A.10 Verify that the rates are the following with $d = 0.40$

t	1	2	3	4	5	6
d_t	0.20	0.32	0.192	0.1152	0.1152	0.0576

$d_1: d_{DB,1} = 0.5d = 0.20$

$d_2:$ By Eq. [16A.15] for DDB:

$$d_{DB,2} = 0.4(1 - 0.2) = 0.32 \quad (\text{selected})$$

By Eq. [16A.16] for SL:

$$d_{SL,2} = 0.8/4.5 = 0.178$$

$d_3:$ DDB: $d_{DB,3} = 0.4(1 - 0.2 - 0.32)$
 $= 0.192 \quad (\text{selected})$

SL: $d_{SL,2} = 0.48/3.5 = 0.137$

$d_4:$ DDB: $d_{DB,4} = 0.4(1 - 0.2 - 0.32 - 0.192)$
 $= 0.1152$

SL: $d_{SL,4} = 0.288/2.5 = 0.1152 \quad (\text{select either})$

Switch to SL occurs in year 4

$d_5:$ Use the SL rate $n = 5$

$$d_{SL,5} = 0.1728/1.5 = 0.1152$$

$d_6:$ $d_{SL,6}$ is the remainder or $1/2$ the d_5 rate.

$$d_{SL,6} = 1 - \sum_{t=1}^5 d_t = 1 - (0.2 + 0.32 + 0.192 + 0.1152 + 0.1152)$$

$$= 0.0576$$

16A.11 $B = \$30,000$ $n = 5$ years $d = 0.40$

Find BV_3 using d_t rates derived from Equations [16A.11] through [16A.13].

$t = 1: d_1 = 1/2(0.4) = 0.2$
 $D_1 = 30,000(0.2) = \$6000$
 $BV_1 = \$24,000$

t = 2: For DDB depreciation, use Eq. [16A.12]

$$d = 0.4$$

$$D_{DB} = 0.4(24,000) = \$9600$$

$$BV_2 = 24,000 - 9600 = \$14,400$$

For SL, if switch is better, in year 2, by Eq. [16A.13].

$$D_{SL} = \frac{24,000}{5-2+1.5} = \$5333$$

Select DDB; it is larger.

t = 3: For DDB, apply Eq. [16A.12] again.

$$D_{DB} = 14,400(0.4) = \$5760$$

$$BV_3 = 14,400 - 5760 = \$8640$$

For SL, Eq. [16A.13]

$$D_S = \frac{14,400}{5-3+1.5} = \$4114$$

Select DDB.

Conclusion: When sold for \$5000, $BV_3 = \$8640$. Therefore, there is a loss of \$3640 relative to the MACRS book value.

NOTE: If Table 16.2 rates are used, cumulative depreciation in % for 3 years is:

$$20 + 32 + 19.2 = 71.2\%$$

$$30,000(0.712) = \$21,360$$

$$BV_3 = 30,000 - 21,360 = \$8640$$

16A.12 Determine MACRS depreciation for $n = 7$ using Equations [16A.11] through [16A.13]. and apply them to $B = \$50,000$. (S) indicates the selected method and amount.

DDB	SL
t = 1: $d = 1/7 = 0.143$ $D_{DB} = \$7150$ (S) $BV_1 = \$42,850$	$D_{SL} = 0.5(1/7)(50,000)$ $= \$3571$
t = 2: $d = 2/7 = 0.286$ $D_{DB} = \$12,255$ (S) $BV_2 = \$30,595$	$D_{SL} = \frac{42,850}{7-2+1.5} = \6592
t = 3: $d = 0.286$ $D_{DB} = \$8750$ (S) $BV_3 = \$21,845$	$D_{SL} = \frac{30,595}{7-3+1.5} = \5563
t = 4: $d = 0.286$ $D_{DB} = \$6248$ (S) $BV_4 = \$15,597$	$D_{SL} = \frac{21,845}{7-4+1.5} = \4854
t = 5: $d = 0.286$ $D_{DB} = \$4461$ (S) $BV_5 = \$11,136$	$D_{SL} = \frac{15,597}{7-5+1.5} = \4456
t = 6: $d = 0.286$ $D_{DB} = \$3185$ (Use SL hereafter)	$D_{SL} = \frac{11,136}{7-6+1.5} = \4454 (S) $BV_6 = \$6682$
t = 7:	$D_{SL} = \frac{6682}{7-7+1.5} = \4454 $BV_7 = \$2228$
t = 8:	$D_{SL} = \$2228$ $BV_8 = 0$

The depreciation amounts sum to \$50,000

Year	Depr	Year	Depr
1	\$ 7150	5	\$4461
2	12,255	6	4454
3	8750	7	4454
4	6248	8	2228

16A.13 (a) The SL rates with the half-year convention for $n = 3$ are:

Year	d rate	Formula
1	0.167	$1/2n$
2	0.333	$1/n$
3	0.333	$1/n$
4	0.167	$1/2n$

(b)

t	1	2	3	4	PW _D
MACRS	\$26,664	35,560	11,848	5928	\$61,253
SL Alternative	\$13,360	26,640	26,640	13,360	\$56,915

The MACRS PW_D is larger by \$4338.

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 17
After-Tax Economic Analysis

17.1 (a) *Graduated rates*: higher taxable incomes pay taxes at higher rates.

Marginal rate: The portion of each taxable dollar of TI that is paid in taxes on the last dollar of income, e.g., 34%.

Indexing: Updating of the TI limits (not the rates) each year to account for inflation and other factors.

(b) $\text{NOI} = \text{gross income} - \text{operating expenses} = \text{GI} - \text{OE}$

Taxable income removes depreciation from the NOI amount; $\text{TI} = \text{GI} - \text{OE} - \text{D}$

NOPAT is TI with taxes removed; or NOI with depreciation and taxes removed:

$$\text{NOPAT} = (\text{TI}) - \text{taxes} = (\text{GI} - \text{OE} - \text{D}) - \text{taxes} = (\text{NOI} - \text{D}) - \text{taxes}$$

17.2 (a) $\text{Taxes} = 22,250 + 0.39(150,000 - 100,000)$
 $= \$41,750$

$$\text{Average rate} = [41,750/150,000](100\%)$$
$$= 27.8\%$$

(b) $\text{Taxes} = 3,400,000 + 0.35(12,000,000 - 10,000,000)$
 $= \$4,100,000$

$$\text{Average rate} = [4,100,000/12,000,000](100\%)$$
$$= 34.2\%$$

17.3 $T_e = 0.05 + (1 - 0.05)(0.35) = 38.25\%$

17.4 (a) Depreciation

(b) Net operating profit after taxes

(c) Taxable income

(d) Gross income

(e) Taxable income

(f) Operating expense

(g) Taxable income

(h) Gross income

(i) Operating expense

17.5 (a) Company 1

$$\begin{aligned}\text{TI} &= \text{Gross income} - \text{Expenses} - \text{Depreciation} \\ &= (1,500,000 + 31,000) - 754,000 - 48,000 \\ &= \$729,000\end{aligned}$$

$$\begin{aligned}\text{Taxes} &= 113,900 + 0.34(729,000 - 335,000) \\ &= \$247,860\end{aligned}$$

Company 2

$$\begin{aligned}\text{TI} &= (820,000 + 25,000) - 591,000 - 18,000 \\ &= \$236,000\end{aligned}$$

$$\begin{aligned}\text{Taxes} &= 22,250 + 0.39(236,000 - 100,000) \\ &= \$75,290\end{aligned}$$

(b) Company 1: $247,860/1.5 \text{ million} = 16.52\%$

$$\text{Company 2: } 75,290/820,000 = 9.2\%$$

(c) Company 1

$$\begin{aligned}\text{Taxes} &= (\text{TI})(T_e) = 729,000(0.34) = \$247,860 \\ \% \text{ error with graduated tax} &= 0\%\end{aligned}$$

Company 2

$$\text{Taxes} = 236,000(0.34) = \$80,240$$

$$\% \text{ error} = \frac{80,240 - 75,290}{75,290} (100\%) = + 6.6\%$$

17.6 $\begin{aligned}\text{Taxes on } \$250,000 &= 22,250 + 0.39(150,000) \\ &= \$80,750\end{aligned}$

(a) Average tax rate = $80,750/250,000 = 32.3\%$

(b) 34% from Table 17.1

(c) Taxes = $113,900 + 0.34(265,000) = \$204,000$

$$\text{Average tax rate} = 204,000/600,000 = 34.0\%$$

(d) Marginal rates are: 39% for \$85,000 that is in \$100,000 to 335,000 TI level
34% for \$265,000 that is in \$335,000 to 10 million level.

Use Eq. [17.4]

$$\begin{aligned}\text{NOPAT} &= \text{TI} - \text{taxes} \\ &= 200,000 - 0.39(85,000) - 0.34(265,000) \\ &= \$76,750\end{aligned}$$

17.7 $T_e = 0.072 + (1 - 0.072)(0.35) = 0.3968$

$$TI = 7.5 \text{ million} - 4.3 \text{ million} = \$3.2 \text{ million}$$

$$\text{Taxes} = 3,200,000(0.3968) = \$1,269,760$$

17.8 (a) Federal taxes = $13,750 + 0.34(15,000) = \$18,850$ (using Table 17-1)

$$\begin{aligned} \text{Average federal rate} &= (18,850/90,000)(100\%) \\ &= 20.9\% \end{aligned}$$

(b) Effective tax rate = $0.07 + (1 - 0.07)(0.209)$
 $= 0.2644$

(c) Total taxes using effective rate = $90,000(0.2644) = \$23,796$

(d) State: $90,000(0.07) = \$6300$

$$\text{Federal: } 90,000[0.209(1 - 0.07)] = 90,000(0.1944) = \$17,493$$

17.9 Without system: Taxes = $150,000(0.39) = \$58,500$

With system: $D = \$8000$
 $TI = 150,000 + 9000 - 2000 - 8000 = \$149,000$
 Taxes = $149,000(0.39) = \$58,110$

$$\text{Tax difference} = 58,500 - 58,110 = \$390 \text{ (reduction)}$$

17.10 (a) $T_e = 0.06 + (1 - 0.06)(0.23) = 0.2762$

(b) Reduced $T_e = 0.9(0.2762) = 0.2486$

Set x = required state rate

$$\begin{aligned} 0.2486 &= x + (1-x)(0.23) \\ x &= 0.0186/0.77 = 0.0242 \quad (2.42\%) \end{aligned}$$

(c) Since $T_e = 22\%$ is lower than the current federal rate of 23%, no state tax could be levied and an interest free grant of 1% of TI, or \$70,000, would have to be made available.

17.11 CFBT includes operating expenses, salvage value, initial investment, and gross income.

17.12 $NOPAT = GI - OE - D - \text{taxes}$
 $CFAT = GI - OE - P + S$

The NOPAT expression deducts depreciation outside the TI and tax computations. The CFAT expression removes the capital investment (or adds salvage) but does not consider depreciation, since it is a non-cash flow.

$$\begin{aligned}
 17.13 \quad & \text{CFBT} = \text{CFAT} + \text{taxes} \\
 & \text{CFBT} = \text{CFAT} + \text{TI}(T_e) \\
 & \text{CFBT} = \text{CFAT} + (\text{GI} - \text{OE} - \text{D})T_e \\
 & \text{CFBT} = \text{CFAT} + (\text{CFBT} - \text{D})T_e \\
 & \text{CFBT}(1 - T_e) = \text{CFAT} - \text{D}T_e \\
 & \text{CFBT} = [\text{CFAT} - \text{D}(T_e)]/(1 - T_e)
 \end{aligned}$$

$$\begin{aligned}
 17.14 \quad & \text{CFAT} = \text{CFBT} - (\text{CFBT} - \text{D})T_e \\
 & 600,000 = \text{CFBT} - (\text{CFBT} - 350,000)0.36
 \end{aligned}$$

$$\text{CFBT} = [600,000 - 350,000(0.36)]/(1 - 0.36) = \$740,625$$

$$17.15 \quad \text{CFAT} = \text{GI} - \text{OE} - \text{P} + \text{S} - (\text{GI} - \text{OE} - \text{D})T_e$$

$$(a) \text{ P and S} = 0$$

$$\text{D} = 200,000(0.0741) = \$14,820$$

$$\begin{aligned}
 \text{CFAT} &= 100,000 - 50,000 - (100,000 - 50,000 - 14,820)(0.40) \\
 &= \$35,928
 \end{aligned}$$

$$(b) \text{ S} = \$20,000$$

$$\text{D} = 200,000(0.0741) = \$14,820$$

$$\begin{aligned}
 \text{CFAT} &= 100,000 - 50,000 + 20,000 - (100,000 - 50,000 - 14,820)(0.40) \\
 &= \$55,928
 \end{aligned}$$

$$17.16 \quad T_e = 0.065 + (1 - 0.065)(0.35) = 0.39225$$

All monetary amounts are in \$ million units

$$\begin{aligned}
 (a) \text{ CFAT} &= \text{GI} - \text{OE} - \text{TI}(T_e) = 48 - 28 - (48 - 28 - 8.2)(0.39225) \\
 &= 20 - 11.8(0.39225) \\
 &= \$15.37 \quad (\$15.37 \text{ million})
 \end{aligned}$$

$$(b) \text{ Taxes} = (48 - 28 - 8.2)(0.39225) = \$4.628 \text{ million}$$

$$\% \text{ of revenue} = 4.628/48 = 9.64\%$$

$$\begin{aligned}
 (c) \text{ NPAT} &= \text{NOPAT} = \text{TI}(1 - T_e) = (48 - 28 - 8.2)(1 - 0.39225) \\
 &= \$7.17 \quad (\$7.17 \text{ million})
 \end{aligned}$$

17.17 $CFBT = CFAT + \text{taxes}$
 $GI - OE = CFAT + (GI - OE - D)(T_e)$

Solve for GI to obtain a general relation for each year t:

$$GI_t = [CFAT + OE(1 - T_e) - DT_e] / (1 - T_e)$$

where: $CFAT = \$2.5 \text{ million}$
 $T_e = 0.08 + (1 - 0.08)(0.20) = 0.264$
 $1 - T_e = 0.736$

Year 1: $GI_1 = [2.5 \text{ million} + 650,000(0.736) - 650,000(0.264)] / 0.736$
 $= \$3,813,587$

Year 2: $GI_2 = [2.5 \text{ million} + 900,000(0.736) - 900,000(0.264)] / 0.736$
 $= \$3,973,913$

Year 3: $GI_3 = [2.5 \text{ million} + 1,150,000(0.736) - 1,150,000(0.264)] / 0.736$
 $= \$4,134,239$

17.18 Estimate before-tax MARR by Equation [10.1]. Tabulate CFBT; calculate AW.

Before-tax MARR = $10\% / (1 - 0.35) = 15.4\%$. (All monetary values are in \$1000 units.)

Year	GI	OE	P and S	CFBT
0			\$-1900	\$-1900
1	\$800	\$-100		700
2	950	-150		800
3	600	-200		400
4	300	-250	700	750

$$\begin{aligned} PW &= -1900 + 700(P/F, 15.4\%, 1) + \dots + 750(P/F, 15.4\%, 4) \\ &= -1900 + 700(0.867) + 800(0.751) + 400(0.651) + 750(0.564) \\ &= \$-9 \end{aligned}$$

$$\begin{aligned} AW &= -9(A/P, 15.4\%, 4) = -9(0.3531) \\ &= \$-3 \quad (\$-3,000) \end{aligned}$$

Equipment *is not* justified using CFBT values.

17.19 Determine MACRS depreciation, taxes and CFAT. Assume negative tax will increase CFAT and AW. (All monetary values are in \$1000 units.)

$$\begin{aligned} TI &= GI - OE - D \\ CFAT &= CFBT - \text{taxes} \end{aligned}$$

Year	GI	OE	P and S	CFBT	D	TI	Taxes	CFAT
0			\$-1900	\$-1900				\$-1900
1	\$800	\$-100		700	\$633	\$ 67	\$23	677
2	950	-150		800	845	-45	-16	816
3	600	-200		400	281	119	42	358
4	300	-250	700	750	141	-91	-32	782

17.20 Determine AW of CFAT at 10%.

$$\begin{aligned}
 AW &= [-1900 + 677(P/F, 10\%, 1) + \dots + 782(P/F, 10\%, 4)](A/P, 10\%, 4) \\
 &= [-1900 + 677(0.9091) + 816(0.8264) + 358(0.7513) + 782(0.6830)](0.31547) \\
 &= 192(0.31547) \\
 &= \$61 \quad (\$61,000)
 \end{aligned}$$

Equipment *is* justified using CFAT values.

17.21 CFBT approximation: Determine before-tax $i^* = 15.1\%$. PW relation is

$$0 = -1900 + 700(P/F, i, 1) + 800(P/F, i, 2) + 400(P/F, i, 3) + 750(P/F, i, 4)$$

After-tax estimated ROR is

$$15.1(1 - 0.35) = 9.8\%$$

CFAT ROR: Determine after-tax $i^* = 14.7\%$, which is considerably higher than the 9.8% approximation from the CFBT values. PW relation is

$$0 = -1900 + 677(P/F, i, 1) + 816(P/F, i, 2) + 358(P/F, i, 3) + 782(P/F, i, 4)$$

Spreadsheet solution for 17.18 to 17.21 follows.

	A	B	C	D	E	F	G	H	I	J
1	AT MARR = 10%			BT MARR = 15.38%		= 10%/(1-0.35)				
2										
3	Year	GI	OE	P and S	CFBT	Depr	TI	Taxes	CFAT	Prob 17.19
4	0			-1900	-1900				-1900	
5	1	800	-100		700	633	67	23	677	
6	2	950	-150		800	845	-45	-16	816	
7	3	600	-200		400	281	119	42	358	
8	4	300	-250	700	750	141	-91	-32	782	
9	AW				-\$3				\$61	Prob 17.20
10	Justified?				No				Yes	
11	Actual ROR				15.1%				14.7%	
12	Approx ROR								9.8%	
13										
14									= E11*(1-0.35)	
15										

17.22 $CFBT = GI - OE - P + S$ (column E)

$$TI = CFBT - D$$

$$\text{Taxes} = 0.4(TI)$$

$$CFAT = CFBT - \text{taxes} \quad (\text{column J})$$

$$NOPAT = TI - \text{taxes} \quad (\text{column I})$$

i^* using IRR function (row 13)

	A	B	C	D	E	F	G	H	I	J
1	Interest									
2	Tax rate	40%								
3										
4	Year	GI	OE	P and S	CFBT	D	TI	Taxes	NOPAT	CFAT
5	0			-250,000	-250,000				0	-250,000
6	1	210,000	-120,000		90,000	-50,000	40,000	16,000	24,000	74,000
7	2	210,000	-120,000		90,000	-80,000	10,000	4,000	6,000	86,000
8	3	160,000	-122,000		38,000	-48,000	-10,000	-4,000	-6,000	42,000
9	4	160,000	-124,000		36,000	-28,800	7,200	2,880	4,320	33,120
10	5	160,000	-126,000		34,000	-28,800	5,200	2,080	3,120	31,920
11	6	140,000	-128,000	0	12,000	-14,400	-2,400	-960	-1,440	12,960
12						-250,000				
13	i^*				7.6%					4.5%

17.23 $D_{SL} = (70,000 - 10,000)/5 = \$12,000$

$$D_{MACRS} = 70,000(0.32) = \$22,400$$

$$\text{Difference in taxes} = (22,400 - 12,000)(0.36) = \$3744$$

\$3744 less taxes paid with MACRS

17.24 *Recovery over 3 years:* SL depreciation is $60,000/3 = \$20,000$ per year

$$\begin{aligned} \text{Year 1-3: Taxes} &= (GI - OE - D)(T_e) \\ &= (32,000 - 10,000 - 20,000)(0.31) \\ &= \$620 \end{aligned}$$

$$\begin{aligned} \text{Years 4-6: Taxes} &= (GI - OE)(T_e) \\ &= (32,000 - 10,000)(0.31) \\ &= \$6820 \end{aligned}$$

$$\text{Total taxes} = 3(620) + 3(6820) = \$22,320$$

$$\begin{aligned} PW_{\text{tax}} &= 620(P/A, 12\%, 3) + 6820(P/A, 12\%, 3)(P/F, 12\%, 3) \\ &= 620(2.4018) + 6820(2.4018)(0.7118) \\ &= \$13,149 \end{aligned}$$

Recovery over 6 years: SL depreciation is $60,000/6 = \$10,000$ per year

$$\begin{aligned}\text{Years 1-6: Taxes} &= (GI - OE - D)(T_e) \\ &= (32,000 - 10,000 - 10,000)(0.31) = \$3,720\end{aligned}$$

$$\text{Total taxes} = 6(3,720) = \$22,320$$

$$\begin{aligned}PW_{\text{tax}} &= 3,720(P/A, 12\%, 6) = 3,720(4.1114) \\ &= \$15,294\end{aligned}$$

Recovery in 3 years has a lower PW_{tax} value; total taxes are the same for both. Spreadsheet solution follows.

	A	B	C	D	E	F	G	H	I	J
1					Recovery over 3 years			Recovery over 6 years		
2	Year	GI	Exp	P and S	Depr	TI	Taxes	Depr	TI	Taxes
3	0			-65,000						
4	1	32,000	-10,000		20,000	2,000	620	10,000	12,000	3,720
5	2	32,000	-10,000		20,000	2,000	620	10,000	12,000	3,720
6	3	32,000	-10,000		20,000	2,000	620	10,000	12,000	3,720
7	4	32,000	-10,000			22,000	6,820	10,000	12,000	3,720
8	5	32,000	-10,000			22,000	6,820	10,000	12,000	3,720
9	6	32,000	-10,000	5,000		22,000	6,820	10,000	12,000	3,720
10	Total				\$60,000	\$72,000	\$22,320	\$60,000	\$72,000	\$22,320
11	PW						\$13,148			\$15,294
12			= B9+C9-E9							

17.25 (a) $D = (20,000 - 0)/3 = \$6,667$

Year	GI	P	OE	D	TI	Taxes	CFAT
0	—	-20	—	—	—	—	-20.000
1	8		-2	6.667	-666	-0.266	6.266
2	15		-4	6.667	4.333	1.733	9.267
3	12	0	-3	6.667	2.333	0.933	8.067
4	10	0	-5	—	5.000	2.000	3.000

(b) For year 1, $D = 20,000(0.3333) = \$6,666$
 $TI = 8,000 - 2,000 - 6,666 = \-666
 $Taxes = -666(0.40) = \$-266$
 $CFAT = 8,000 - 2,000 - (-266) = \$6,266$

In \$1000 units

Year	GI	S	OE	D	TI	Taxes	CFAT
0	—	-20	—	—	—	—	-20.000
1	8		-2	6.666	-0.666	-0.266	6.266
2	15		-4	8.890	2.110	0.844	10.156
3	12	0	-3	2.962	6.038	2.415	6.585
4	10	0	-5	1.482	3.518	1.407	3.593

17.26 $CFAT = GI - OE - P + S - \text{taxes}$
 $NOPAT = TI - \text{taxes}$

(a) Example for Year 2: $CFAT = 15 - 4 - [(15 - 4 - 6)(0.32)] = 9.4$
 $NOPAT = 5 - 1.6 = 3.4$

Year	GI	OE	P	D	TI	Taxes	CFAT	NOPAT
0	—	—	-30	—	—	—	-30.0	
1	8	-2		6	0	0.0	6.0	0.00
2	15	-4		6	5	1.6	9.4	3.40
3	12	-3		6	3	0.96	8.04	2.04
4	10	-5		6	-1	-0.32	5.32	-0.68

(b)

Year	GI	OE	P	D	TI	Taxes	CFAT	NOPAT
0	—	—	-30	—	—	—	-30.0	
1	8	-2	-	6	0	0.0	6.0	0.0
2	15	-4	-	9.6	1.40	0.448	10.552	0.952
3	12	-3	-	5.76	3.24	1.037	7.963	2.203
4	10	-5	-	3.456	1.544	0.494	4.506	1.05

17.27 (a) For SL depreciation with $n = 3$ years, $D_t = \$50,000$ per year, $\text{Taxes} = TI(0.35)$

Year	CFBT	D	TI	Taxes
1-3	\$80,000	\$50,000	\$30,000	\$10,500

$$PW_{\text{tax}} = 10,500(P/A, 15\%, 3) = 10,500(2.2832) = \$23,974$$

For MACRS depreciation, use Table 16.2 rates.

Year	CFBT	d	D	TI	Taxes
1	\$80,000	33.33%	\$49,995	\$30,005	\$10,502
2	80,000	44.45	66,675	13,325	4,664
3	80,000	14.81	22,215	57,785	20,224
4	0	7.41	11,115	-11,115	-3,890

$$PW_{\text{tax}} = 10,502(P/F, 15\%, 1) + \dots - 3890(P/F, 15\%, 4) = \$23,733$$

MACRS has only a slightly lower PW_{tax} value.

(b) Total taxes are the same: SL is $3(10,500) = \$31,500$

$$\text{MACRS is } 10,502 + \dots - 3890 = \$31,500$$

17.28 (a) *MACRS depreciation*

Year	P and CFBT	Rate	Depr	TI	Taxes
0	-200,000				
1	75,000	0.2	40,000	35,000	13,300
2	75,000	0.32	64,000	11,000	4,180
3	75,000	0.192	38,400	36,600	13,908
4	75,000	0.1152	23,040	51,960	19,745
5	75,000	0.1152	23,040	51,960	19,745
6	75,000	0.0576	11,520	63,480	24,122
7	75,000	0	0	75,000	28,500
8	75,000	0	0	75,000	28,500
Total					\$152,000

$$PW_{\text{tax}} = 13,300(P/F, 8\%, 1) + 4,180(P/F, 8\%, 2) + \dots + 28,500(P/F, 8\%, 8) \\ = \$102,119$$

$$\text{Total taxes} = \$152,000$$

Straight line depreciation

$$\text{Depreciation is } 200,000/8 = \$25,000 \text{ per year}$$

$$\text{Taxes} = (75,000 - 25,000)(0.38) = \$19,000 \text{ per year}$$

$$\text{Total taxes} = 8(19,000) = \$152,000$$

$$PW_{\text{tax}} = 19,000(P/A, 8\%, 8) = 19,000(5.7466) \\ = \$109,185$$

MACRS is preferable with a lower PW_{tax} value.

(b) Total taxes are \$152,000 for both methods.

17.29 Find the difference between PW of CFBT and CFAT

Year	CFBT	d	D	TI	Taxes	CFAT
1	\$10,000	0.20	\$1,800	\$8,200	\$3,280	\$6,720
2	10,000	0.32	2,880	7,120	2,848	7,152
3	10,000	0.192	1,728	8,272	3,309	6,691
4	10,000	0.1152	1,037	8,963	3,585	6,415
5	5,000	0.1152	1,037	3,963	1,585	3,415
6	5,000	0.0576	518	4,482	1,793	3,207

$$PW_{CFBT} = 10,000(P/A, 10\%, 4) + 5000(P/A, 10\%, 2)(P/F, 10\%, 4) = \$37,626$$

$$PW_{CFAT} = 6720(P/F, 10\%, 1) + \dots + 3207(P/F, 10\%, 6) = \$25,359$$

Cash flow lost to taxes is \$12,267 in PW terms.

17.30 (a) At sale time, there will be depreciation recapture of $DR = \$100,000$, since MACRS will depreciate to zero after 4 years.

(b) TI will increase by the depreciation recapture of \$100,000

$$DR = \text{Selling Price} - BV = 100,000 - 0 = \$100,000$$

DR is taxed as regular taxable income

$$\text{Taxes will increase by } TI(T_e) = 100,000(0.35) = \$35,000$$

17.31 (a)

Year	GI - OE	P and SP	D	TI	Taxes	CFAT
0		\$-100,000				\$-100,000
1	\$25,000		\$20,000	\$5,000	\$1,500	23,500
2	25,000		20,000	5,000	1,500	23,500
3	25,000		20,000	5,000	1,500	23,500
4	25,000		20,000	5,000	1,500	23,500
5	25,000	20,000	20,000	5,000	1,500	43,500

$$(b) PW_D = 20,000(P/A, 9\%, 5) = 20,000(3.8897) = \$77,794$$

$$PW_{\text{tax}} = 1500(P/A, 9\%, 5) = \$5835$$

$$\begin{aligned} PW_{CFAT} &= -100,000 + 23,500(P/A, 9\%, 5) + 20,000(P/F, 9\%, 5) \\ &= -100,000 + 23,500(3.8897) + 20,000(0.6499) \\ &= \$4406 \end{aligned}$$

There is no depreciation recapture in year 5 for the selling price that is \$20,000 higher than $BV_5 = 0$ in Country 1.

17.32 (a)

Year	GI - OE	P and SP	D	TI	Taxes	CFAT
0		\$-100,000				\$-100,000
1	\$25,000		\$33,333	\$-8,333	\$-2,500	27,500
2	25,000		44,444	-19,444	-5,833	30,833
3	25,000		14,815	10,185	3,056	21,944
4	25,000		7,407	17,593	5,278	19,722
5	25,000	20,000	0	45,000	13,500	31,500

$$(b) PW_D = 33,333(P/F, 9\%, 1) + \dots + 7407(P/F, 9\%, 4) \\ = \$84,675$$

In year 5, there is depreciation recapture added to make TI larger

$$DR = SP - BV = 20,000 - 0 = \$20,000 = S$$

$$TI = GI - OE - D + DR \\ = 25,000 - 0 + 20,000 \\ = \$45,000$$

$$PW_{tax} = -2500(P/F, 9\%, 1) - 5833(P/F, 9\%, 2) + \dots + 13,500(P/F, 9\%, 5) \\ = \$7669$$

$$PW_{CFAT} = -100,000 + 27,500(P/F, 9\%, 1) + \dots + 31,500(P/F, 9\%, 5) \\ = -100,000 + 27,500(0.9174) + \dots + 31,500(0.6499) \\ = \$2569$$

17.33 (a)

Year	GI - OE	P and SP	D	TI	Taxes	CFAT
0		\$-100,000				\$-100,000
1	\$25,000		\$40,000	\$-15,000	\$-4,500	29,500
2	25,000		24,000	1,000	300	24,700
3	25,000		14,400	10,600	3,180	21,820
4	25,000		1,600	23,400	7,020	17,980
5	25,000	20,000	0	25,000	7,500	37,500

$$(b) PW_D = 40,000(P/F, 9\%, 1) + \dots + 1600(P/F, 9\%, 4) = \$69,150$$

In year 5, there is *no* depreciation recapture, since DDB took the value down to $S = \$20,000$ and the simulator was sold for this amount.

$$PW_{tax} = -4500(P/F, 9\%, 1) + 300(P/F, 9\%, 2) + \dots + 7,500(P/F, 9\%, 5) \\ = \$8427$$

$$PW_{CFAT} = -100,000 + 29,500(P/F, 9\%, 1) + \dots + 37,500(P/F, 9\%, 5) \\ = -100,000 + 29,500(0.9174) + \dots + 37,500(0.6499) \\ = \$1811$$

17.34 Spreadsheet solutions for problems 17.31-17.33 and this problem follow.

Best country selections:

Country 1: Total taxes, PW of taxes and CFAT

Country 2: PW of depreciation

Highest PW of depreciation is selected, so MACRS (country 2) wins here. Taxes are best when low (country 1). Country 1 wins on PW of CFAT, even though SL depreciation is applied, because the DR in year 5 is not taxed. This increases the CFAT considerably in the last year.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1			P and	COUNTRY 1 -- STRAIGHT LINE				COUNTRY 2 -- MACRS				COUNTRY 3 -- DDB			
2	Year	GI - E	SP	Depr	TI	Taxes	CFAT	Depr	TI	Taxes	CFAT	Depr	TI	Taxes	CFAT
3	0		-100,000				-100,000				-100,000				-100,000
4	1	25,000		20,000	5,000	1,500	23,500	33,333	-8,333	-2,500	27,500	40,000	-15,000	-4,500	29,500
5	2	25,000		20,000	5,000	1,500	23,500	44,444	-19,444	-5,833	30,833	24,000	1,000	300	24,700
6	3	25,000		20,000	5,000	1,500	23,500	14,815	10,185	3,056	21,944	14,400	10,600	3,180	21,820
7	4	25,000		20,000	5,000	1,500	23,500	7,407	17,593	5,278	19,722	1,600	23,400	7,020	17,980
8	5	25,000	20,000	20,000	5,000	1,500	43,500	0	45,000	13,500	31,500	0	25,000	7,500	37,500
9	Total			100,000		7,500	37,500	100,000		13,500	31,500	80,000		13,500	31,500
10	PW @ 9%			77,793		5,834	4,405	84,676		7,669	2,571	69,150		8,427	1,813
11	ROR						10.5%				10.0%				9.7%
12	SUMMARY TABLE														
13		Total	PW at 9%												
14	Country	taxes	Depr	Taxes	CFAT										
15	1	7,500	77,793	5,834	4,405										
16	2	13,500	84,676	7,669	2,571										
17	3	13,500	69,150	8,427	1,813										

Note: In column B, E is used instead of OE for operating expenses.

17.35 $DR = 350,000 - 100,800 = \$249,200$

$CG = 385,000 - 350,000 = \$35,000$

17.36 $BV_4 = 355,000 - 355,000(0.10 + 0.18 + 0.144 + 0.1152)$
 $= \$163,584$

$DR = 190,000 - 163,584$
 $= \$26,416$

17.37 (a) $BV_2 = 28,500 - 28,500(0.3333 + 0.4445)$
 $= \$6333$

$CL = 6333 - 5000 = \$1333$

(b) Capital loss can only be used to offset capital gains. This will reduce taxes on the gains. If there are no gains, carry-forward and carry-back allowances may apply.

17.38 (a) Selling price = $0.4(150,000) = \$60,000$
 $BV_4 = 150,000(1 - 0.6876) = \$46,860$
 $DR = SP - BV_4 = \$13,140$
Taxes = $DR(T_c) = 13,140(0.35) = \4599

(b) $CG = \$10,000$
 $DR = 0.3333(100,000) = \$33,330$
 $TI = \$43,330$
 $Taxes = 43,330(0.35) = \$15,166$

(c) Land does not depreciate, but gains are taxed

$$CG = TI = 0.10(1.8 \text{ million}) = \$180,000$$

$$Taxes = 180,000(0.35) = \$63,000$$

(d) $CL = 5000 - 500 = \$4500$
 $TI = \$-4500$

$$\text{Tax savings} = 0.35(-4500) = \$-1575$$

(e) $DR = TI = \$2000$
 $Taxes = 2000(0.35) = \$700$

17.39 Land: $CG = \$75,000$
 Building: $CL = \$25,000$
 Asset 1: $DR = 19,500 - 15,500 = \$4000$
 Asset 2: $DR = 12,500 - 5,000 = \$7500$

17.40 Effective tax rate $= 0.042 + (1 - 0.042)(0.34)$
 $= 0.3677$

$$\text{Before-tax ROR} = 0.07 / (1 - 0.3677) = 0.111 \quad (11.1\%)$$

An 11.1 % before-tax rate is equivalent to 7% after taxes.

17.41 After-tax ROR $= 24(1 - 0.35) = 15.6\%$

17.42 Before tax ROR: $0 = -500,000 + 230,000(P/A, i^*, 3) + 100,000(P/F, i^*, 3)$
 $i^* = 25.0\% \quad (\text{spreadsheet})$

$$\text{After-tax ROR estimate} = 25.0(1 - 0.35) = 16.25\%$$

17.43 $0.12 = 0.08 / (1 - \text{tax rate})$
 $1 - \text{tax rate} = 0.667$
 $\text{Tax rate} = 0.333 \quad (33.3\%)$

17.44 Small company: After-tax ROR $= 0.18(1 - 0.28) = 0.1296 \quad (12.96\%)$
 Conclusion: Accept at after-tax MARR = 12%

Large corporation: After-tax ROR $= 0.18(1 - 0.34) = 0.1188 \quad (11.88\%)$
 Conclusion: Reject at after-tax MARR = 12%

17.45 Method A: Years 1-5: $CFBT = 35,000 - 15,000 = 20,000$

$$D = (100,000 - 10,000)/5 = \$18,000$$

$$\text{Taxes} = (20,000 - 18,000)(0.34) = \$680$$

$$CFAT = 20,000 - 680 = \$19,320$$

$$\begin{aligned} AW_A &= -100,000(A/P, 7\%, 5) + 19,320 + 10,000(A/F, 7\%, 5) \\ &= \$-3330 \end{aligned}$$

Method B: Years 1-5: $CFBT = 45,000 - 6,000 = 39,000$

$$D = (150,000 - 20,000)/5 = \$26,000$$

$$\text{Taxes} = (39,000 - 26,000)(0.34) = \$4420$$

$$CFAT = 39,000 - 4420 = \$34,580$$

$$\begin{aligned} AW_A &= -150,000(A/P, 7\%, 5) + 34,580 + 20,000(A/F, 7\%, 5) \\ &= \$-1474 \end{aligned}$$

Method B is selected; the same as that when MACRS is detailed.

17.46 (a) $PW_A = -15,000 - 3000(P/A, 14\%, 10) + 3000(P/F, 14\%, 10)$
 $= -15,000 - 3000(5.2161) + 3000(0.2697)$
 $= \$-29,839$

$$\begin{aligned} PW_B &= -22,000 - 1500(P/A, 14\%, 10) + 5000(P/F, 14\%, 10) \\ &= -22,000 - 1500(5.2161) + 5000(0.2697) \\ &= \$-28,476 \end{aligned}$$

Select B with a slightly smaller PW value.

(b) All costs generate tax savings.

Machine A

$$\text{Annual depreciation} = (15,000 - 3,000)/10 = \$1200$$

$$\text{Tax savings} = (AOC + D)0.5 = 4200(0.5) = \$2100$$

$$CFAT = -3000 + 2100 = \$-900$$

$$\begin{aligned} PW_A &= -15,000 - 900(P/A, 7\%, 10) + 3000(P/F, 7\%, 10) \\ &= -15,000 - 900(7.0236) + 3000(0.5083) \\ &= \$-19,796 \end{aligned}$$

Machine B

$$\text{Annual depreciation} = (22,000 - 5000)/10 = \$1700$$

$$\text{Tax savings} = (1500 + 1700)(0.50) = \$1600$$

$$CFAT = -1500 + 1600 = \$100$$

$$\begin{aligned}
 PW_B &= -22,000 + 100(P/A, 7\%, 10) + 5000(P/F, 7\%, 10) \\
 &= -22,000 + 100(7.0236) + 5000(0.5083) \\
 &= \$-18,756
 \end{aligned}$$

Select machine B.

(c) MACRS with $n = 5$ and a DR in year 10, which is a tax, not a tax savings.

Tax savings = $(AOC + D)(0.5)$, years 1-6

CFAT = $-AOC + \text{tax savings}$, years 1-10

Machine A

Year 10 has a DR tax of $3,000(0.5) = \$1500$

Year	P or S	AOC	Depr	Tax savings	CFAT
0	\$-15,000	-	-	-	\$-15,000
1		\$3000	\$3000	\$3000	0
2		3000	4800	3900	+900
3		3000	2880	2940	-60
4		3000	1728	2364	-636
5		3000	1728	2364	-636
6		3000	864	1932	-1068
7		3000	0	1500	-1500
8		3000	0	1500	-1500
9		3000	0	1500	-1500
10		3000	0	1500	-1500
10	3000	-	-	-1500	+1500

$$\begin{aligned}
 PW_A &= -15,000 + 0 + 900(P/F, 7\%, 2) + \dots - 1,500(P/F, 7\%, 9) \\
 &= \$-18,536
 \end{aligned}$$

Machine B

Year 10 has a DR tax of $5,000(0.5) = \$2,500$

Year	P or S	AOC	Depr	Tax savings	CFAT
0	\$-22,000	-	-	-	\$-22,000
1		\$1500	\$4400	\$2950	1450
2		1500	7040	4270	2770
3		1500	4224	2862	1362
4		1500	2534	2017	517
5		1500	2534	2017	517
6		1500	1268	1384	-116
7		1500	0	750	-750
8		1500	0	750	-750
9		1500	0	750	-750
10		1500	0	750	-750
10	5000	-	-	-2500	2500

$$PW_B = -22,000 + 1450(P/F, 7\%, 1) + \dots + 2500(P/F, 7\%, 10) \\ = \$-16,850$$

Select machine B, as above.

17.47

<u>Alternative A</u>						
Year	P & S	GI - OE	D	TI	Taxes	CFAT
0	-8000	-	-	-	-	-8000
1		3500	2666	834	333	3167
2		3500	3556	-56	-22	3522
3		3500	1185	2315	926	2574
4	0	0	593	-593	-237	237

$$PW_A = -8000 + 3167(P/F, 8\%, 1) + 3522(P/F, 8\%, 2) + 2574(P/F, 8\%, 3) + 237(P/F, 8\%, 4) \\ = \$169$$

<u>Alternative B</u>						
Year	P & S	GI - OE	D	TI	Taxes	CFAT
0	-13,000	-	-	-	-	-13,000
1		5000	4333	667	267	4733
2		5000	5779	-779	-311	5311
3		5000	1925	3075	1230	3770
4	0	0	963	-963	-385	385
	2000	-	-	2000	800	1200

$$PW_B = -13,000 + 4733(P/F, 8\%, 1) + 5311(P/F, 8\%, 2) + 3770(P/F, 8\%, 3) + 385(P/F, 8\%, 4) \\ + 1200(P/F, 8\%, 4) \\ = \$93$$

Select alternative A

17.48 (a) Classical SL; $n = 5$ year recovery period; $D = (2,500,000 - 0)/5 = \$500,000$

All monetary values are in \$1000 units.

Year 1

$$\text{Taxes} = (1,500 - 500) (0.30) = \$300$$

$$\text{CFAT} = 1,500 - 300 = \$1,200$$

Years 2 - 5

$$\text{Taxes} = (300 - 500) (0.30) = \$-60$$

$$\text{CFAT} = 300 - (-60) = \$360$$

The rate of return relation over 5 years is:

$$0 = -2,500 + 1,200(P/F, i^*, 1) + 360(P/A, i^*, 4)(P/F, i^*, 1)$$

$$i^* = 2.36 \% \quad (\text{interpolation between } 2\% \text{ and } 3\%)$$

(b) Use MACRS with $n = 5$ year recovery period. In \$1000 units,

Year	P	GI-OE	Depr	TI	Taxes	CFAT
0	\$-2,500	-	-	-	-	\$-2500
1		\$1,500	\$500	\$1,000	\$300	1,200
2		300	800	-500	-150	450
3		300	480	-180	-54	354
4		300	288	12	4	296
5		300	288	12	4	296

The ROR relation and i^* over 5 years are:

$$0 = -2500 + 1200(P/F, i^*, 1) + \dots + 296(P/F, i^*, 5)$$

$$i^* = 1.71 \% \quad (\text{interpolation between } 1\% \text{ and } 2\%)$$

The 5-year after-tax ROR for MACRS is less than that for SL depreciation, since not all of the first cost is written off in 5 years using MACRS.

(a) and (b) Spreadsheet solution, in \$1000 units, shows MACRS has a lower ROR.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Tax rate =	30%	SL depr =	\$500								
2				Straight Line Depreciation				MACRS Depreciation				
3	Year	P	GI - E	Depr	TI	Taxes	CFAT	Rate	Depr	TI	Taxes	CFAT
4	0	-2500	0				\$(2,500)	0				\$(2,500)
5	1		1500	500	1000	300	\$ 1,200	0.2	500	1000	300	\$ 1,200
6	2		300	500	-200	-60	\$ 360	0.32	800	-500	-150	\$ 450
7	3		300	500	-200	-60	\$ 360	0.192	480	-180	-54	\$ 354
8	4		300	500	-200	-60	\$ 360	0.1152	288	12	4	\$ 296
9	5		300	500	-200	-60	\$ 360	0.1152	288	12	4	\$ 296
10	5-yr ROR						2.36%					1.72%
11												
12												
13												
14												
15												

Note: In column C, E is used instead of OE for operating expenses.

17.49 For a 10% after-tax return, solve for n in an after-tax PW relation.

$$-78,000 + 15,000(P/A, 10\%, n) = 0$$

$$(P/A, 10\%, n) = 5.2$$

$$n = 7.7 \text{ years (interpolation)}$$

Keep the inspection equipment for 2.7 more years.

(Note: The spreadsheet function = NPER(10%, 15000, -78000) will display the n value.)

17.50 (a) For a *capital loss*, it is the difference between sales price and the asset's book value.

For a *capital gain*, it is the difference between the sales price and the unadjusted basis (first cost) of the asset.

(b) The AW of the *challenger* is affected in year 0 by the capital gains tax. If it is a capital loss, the netting of losses against gains can affect AW.

17.51 A capital loss will result in reduced taxes to the company. The *tax savings* will be applied to the *challenger*, since the savings is realized only if the challenger is bought. Thus, a capital loss will render the challenger more attractive.

17.52 (a) Defender: $CL = BV - \text{Sales price} = [300,000 - 2(60,000)] - 150,000 = \$-30,000$

The CL of \$-30,000 by the defender will result in tax consequences as follows:

Taxes = $-30,000(0.35) = \$-10,500$, which represents a *tax savings* for the *challenger* in year 0.

Challenger: CFAT, year 0 = $-420,000 + 10,500 = \$-409,500$

Defender: CFAT, year 0 = $\$-150,000$

(b) Defender: $TI = -120,000 - 60,000 = \$-180,000$
 $Taxes = 180,000(0.35) = \$-63,000$
 $CFAT = -120,000 - (-63,000) = \$-57,000$

Challenger: $TI = -30,000 - 140,000 = \$-170,000$
 $Taxes = 170,000(0.35) = \$-59,500$
 $CFAT = -30,000 - (-59,500) = \$29,500$

(c) $AW_D = -150,000(A/P, 15\%, 3) - 57,000$
 $= -150,000(0.43798) - 57,000$
 $= \$-122,697$

$$AW_C = -409,500(A/P, 15\%, 3) + 29,500$$
$$= -409,500(0.43798) + 29,500$$
$$= \$-149,853$$

Therefore, keep the defender

17.53 $TI, \text{ next year} = -70,000 - 69,960 = -139,960$

$Taxes, \text{ next year} = -139,960(0.35) = \$-48,986$ (tax savings)

$CFAT \text{ next year} = -70,000 + 48,986 = \$-21,014$

17.54 Find after-tax PW of costs over 4-year study period. DR is involved on the defender trade in.

Defender

SL depreciation is $(45,000 - 5000)/8 = \$5000$

$$\text{Annual tax} = (-OE - D)(T_c)$$
$$= (-7000 - 5000)(0.35)$$
$$= \$-4200 \text{ (savings)}$$

$$CFAT = CFBT - \text{taxes}$$
$$= -7000 - (-4200)$$
$$= \$-2800$$

$$PW_D = -35,000 + 5000(P/F, 12\%, 4) - 2800(P/A, 12\%, 4)$$
$$= -35,000 + 5000(0.6355) - 2800(3.0373)$$
$$= \$-40,327$$

Challenger

MACRS depreciation over $n = 5$, but only 4 years apply. Defender trade depreciation recapture must be included.

$$\text{Defender BV}_3 = 45,000 - 3(5000) = \$30,000$$

$$\text{SP} = \$35,000$$

$$\text{DR} = \text{SP} - \text{BV} = 5,000$$

$$\text{Tax on DR} = 5,000(0.35) = \$1750$$

$$\text{Challenger first cost} = -24,000 - 1750 = \$-25,750$$

MACRS depreciation is based on \$24,000 first cost

Year	Exp	P and S	Rate	Depr	TI	Taxes	CFAT
0		-25,750					-25,750
1	-8000		0.3333	8,000	-16,000	-5,600	-2,400
2	-8000		0.4445	10,668	-18,668	-6,534	-1,466
3	-8000		0.1481	3,554	-11,554	-4,044	-3,956
4	-8000	0	0.0741	1,778	-9,778	-3,422	-4,578

$$\begin{aligned} \text{PW}_C &= -25,750 - 2400(\text{P/F}, 12\%, 1) - \dots - 4578(\text{P/F}, 12\%, 4) \\ &= \$-34,787 \end{aligned}$$

Select the *challenger* with a lower PW of cost. Spreadsheet solution follows.

	A	B	C	D	E	F	G
1	DEFENDER						
2	Year	AOC	P and S	Depr	TI	Taxes	CFAT
3	0		-35,000				-35,000
4	1	-7,000		5,000	-12,000	-4,200	-2,800
5	2	-7,000		5,000	-12,000	-4,200	-2,800
6	3	-7,000		5,000	-12,000	-4,200	-2,800
7	4	-7,000	5,000	5,000	-12,000	-4,200	2,200
8	PW						-40,327
9							
10	CHALLENGER						
11	Year	AOC	P and S	DEPR	TI	Taxes	CFAT
12	0		-25,750				-25,750
13	1	-8,000		8,000	-16,000	-5,600	-2,400
14	2	-8,000		10,667	-18,667	-6,533	-1,467
15	3	-8,000		3,556	-11,556	-4,044	-3,956
16	4	-8,000	0	1,778	-9,778	-3,422	-4,578
17	PW						-34,787
18	<div> $\text{DR} = 35000 - (45000 - 3(5000)) = 5000$ $\text{DR tax} = 5000(0.35) = 1750$ First cost relation is: $= -24000 - 0.35(35000 - (45000 - 3(5000)))$ </div>						
19							
20							
21							
22							
23							

17.55 Determine AW_C and compare it with $AW_D = \$2100$. Defender has DR on trade since $BV = 0$ now.

$$DR = SP - BV = 25,000 - 0 = \$25,000$$

$$\text{Tax on DR} = 25,000(0.3) = \$7500$$

$$\text{Challenger first cost} = -75,000 - 7500 = \$-82,500$$

$$\text{SL depreciation} = (75,000 - 15,000)/10 = \$6000 \text{ per year}$$

$$\begin{aligned} \text{Years 1-10, CFAT} &= \text{CFBT} - (\text{CFBT} - D)(T_e) \\ &= 15,000 - (15,000 - 6000)(0.3) \\ &= \$12,300 \end{aligned}$$

$$\begin{aligned} AW_C &= -82,500(A/P, 8\%, 10) + 15,000(A/F, 8\%, 10) + 12,300 \\ &= -82,500(0.14903) + 15,000(0.06903) + 12,300 \\ &= \$1040 \end{aligned}$$

Retain the defender; it has a larger AW value.

17.56 Study period is fixed at 3 years.

1. Succession options

Option	Defender	Challenger
1	2 years	1 year
2	1	2
3	0	3

2. Find AW for defender and challenger for 1, 2 and 3 years of retention.

Defender

$$AW_{D1} = \$300,000 \quad AW_{D2} = \$240,000$$

Challenger

No tax effect if (defender) contract is cancelled. Calculate CFAT for 1, 2, and 3 years of ownership. Tax rate is 35%. There is DR each year.

Year	OE, \$	d	D, \$	BV, \$	SP, \$	DR, \$	TI, \$	Tax savings, \$	CFAT, \$
0	-	-	-	800,000	-	-	-	-	-800,000
1	120,000	0.333	266,640	533,360	600,000	66,640	-320,000	-112,000	592,000
2	120,000	0.445	355,600	177,760	400,000	222,240	-253,360	-88,676	368,676
3	120,000	0.148	118,480	59,280	200,000	140,720	-97,760	-34,216	114,216

$$TI = -OE - D + DR$$

$$\begin{aligned}\text{Year 1: TI} &= -120,000 - 266,640 + 66,640 = \$-320,000 \\ \text{Year 2: TI} &= -120,000 - 355,600 + 222,240 = \$-253,360 \\ \text{Year 3: TI} &= -120,000 - 118,480 + 140,720 = \$-97,760\end{aligned}$$

$$\text{CFAT} = -\text{OE} + \text{SP} - \text{taxes} \quad (\text{where negative taxes are a tax savings})$$

$$\begin{aligned}\text{Year 1: } &-120,000 + 600,000 - (-112,000) = \$592,000 \\ \text{Year 2: } &-120,000 + 400,000 - (-88,676) = \$368,676 \\ \text{Year 3: } &-120,000 + 200,000 - (-34,216) = \$114,216\end{aligned}$$

$$\begin{aligned}\text{AW}_{\text{C1}} &= -800,000(\text{A/P}, 10\%, 1) + 592,000 \\ &= -800,000(1.10) + 592,000 \\ &= \$-288,000\end{aligned}$$

$$\begin{aligned}\text{AW}_{\text{C2}} &= -800,000(\text{A/P}, 10\%, 2) + [592,000(\text{P/F}, 10\%, 1) + 368,676(\text{P/F}, 10\%, 2)](\text{A/P}, 10\%, 2) \\ &= -800,000(0.57619) + [592,000(0.9091) + 368,676(0.8264)](0.57619) \\ &= \$+24,696\end{aligned}$$

$$\begin{aligned}\text{AW}_{\text{C3}} &= -800,000(\text{A/P}, 10\%, 3) + [592,000(\text{P/F}, 10\%, 1) + 368,676(\text{P/F}, 10\%, 2) \\ &\quad + 114,216(\text{P/F}, 10\%, 3)](\text{A/P}, 10\%, 3) \\ &= -800,000(0.40211) + [592,000(0.9091) + 368,676(0.8264) \\ &\quad + 114,216(0.7513)](0.40211) \\ &= \$+51,740\end{aligned}$$

Selection of best option: Determine AW for each option first.

Summary of cost/year and project AW

Option	Year			AW
	1	2	3	
1	\$-240,000	\$-240,000	\$-288,000	\$-254,493
2	-300,000	24,696	24,696	-94,000
3	51,740	51,740	51,740	+51,740

Conclusion: Replace now with the challenger. Engineering VP has the better economic strategy.

- 17.57** (a) Study period is set at 5 years. The only option is the defender for 5 years and the challenger for 5 years.

Defender

$$\begin{aligned}\text{First cost} &= \text{Sale} + \text{Upgrade} \\ &= 15,000 + 9000 \\ &= \$24,000\end{aligned}$$

Upgrade SL depreciation = \$3000 year (years 1-3 only)

AOC, years 1-5: = \$6000

Tax savings, years 1-3: = $(6000 + 3000)(0.4) = \$3600$

Tax savings, year 4-5: = $6000(0.4) = \$2,400$

Actual cost, years 1-3: = $6000 - 3600 = \$2400$

Actual cost, years 4-5: = $6000 - 2400 = \$3600$

$$\begin{aligned}AW_D &= -24,000(A/P, 12\%, 5) - 2400 - 1200(F/A, 12\%, 2)(A/F, 12\%, 5) \\&= -24,000(0.27741) - 2400 - 1200(2.12)(0.15741) \\&= \$-9458\end{aligned}$$

Challenger

DR on defender = \$15,000

DR tax = $15,000(0.4) = \$6000$

First cost + DR tax = $40,000 + 6000 = \$46,000$

Depreciation = $40,000/5 = \$8,000$

Operating expenses = \$7,000 (years 1-5)

Tax savings = $(8000 + 7000)(0.4) = \$6,000$

Actual cost = $7000 - 6000 = \$1000$ (years 1-5)

$$\begin{aligned}AW_C &= -46,000(A/P, 12\%, 5) - 1000 \\&= -46,000(0.27741) - 1000 \\&= \$-13,761\end{aligned}$$

Retain the defender since the AW of cost is smaller.

- (b) AW_C will become *less* costly, because there is revenue from the challenger's sale between \$2000 and \$4000 in year 5. However, the revenue will be reduced by the 40% tax on DR.

- 17.58** (a) Before taxes: Spreadsheet is similar to Figure 17-8 with RV in a separate cell (D1) from defender first cost. Let $RV = 0$ to start and establish CFAT column and AW of CFAT series. If tax rate (F1) is set to 0%, and Solver is used, $RV = \$415,668$ is determined.

Spreadsheet is below with Solver parameters. Note that the equality between AW of CFAT values is guaranteed by using the constraint $I12 = I29$ and establishing a minimum (or maximum) value so Solver can find a solution.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	First cost =	(\$550,000)	RV =	\$ 415,668	Tax rate =	0%										
2																
3	Asset age	Year	P or SV	Expenses	SL depr	Current BV	TI	Taxes	CFAT							
4	3	0	(415,668)			400,000			(415,668)							
5	4	1		(27,000)	50,000	350,000	(77,000)	-	(27,000)							
6	5	2		(27,000)	50,000	300,000	(77,000)	-	(27,000)							
7	6	3		(27,000)	50,000	250,000	(77,000)	-	(27,000)							
8	7	4		(27,000)	50,000	200,000	(77,000)	-	(27,000)							
9	8	5		(27,000)	50,000	150,000	(77,000)	-	(27,000)							
10	9	6		(27,000)	50,000	100,000	(77,000)	-	(27,000)							
11	10	7	50,000	(27,000)	50,000	50,000	(77,000)	-	23,000							
12	AW of CFAT @ 12%								(\$113,124)							
13																
14	P =	(\$400,000)														
15	Year	P or SV	Expenses	SL depr	BV	TI	Taxes	CFAT								
16	0	(400,000)			400,000	15,668	0	(400,000)								
17	1		(50,000)	30,417	369,583	(80,417)	0	(50,000)								
18	2		(50,000)	30,417	339,167	(80,417)	0	(50,000)								
19	3		(50,000)	30,417	308,750	(80,417)	0	(50,000)								
20	4		(50,000)	30,417	278,333	(80,417)	0	(50,000)								
21	5		(50,000)	30,417	247,917	(80,417)	0	(50,000)								
22	6		(50,000)	30,417	217,500	(80,417)	0	(50,000)								
23	7		(50,000)	30,417	187,083	(80,417)	0	(50,000)								
24	8		(50,000)	30,417	156,667	(80,417)	0	(50,000)								
25	9		(50,000)	30,417	126,250	(80,417)	0	(50,000)								
26	10		(50,000)	30,417	95,833	(80,417)	0	(50,000)								
27	11		(50,000)	30,417	65,417	(80,417)	0	(50,000)								
28	12	35,000	(50,000)	30,417	35,000	(80,417)	0	(15,000)								
29	AW of CAFT @ 12%								(\$113,124)							

Solver Parameters	
Set Target Cell:	\$I\$12
Equal To:	<input type="radio"/> Max <input checked="" type="radio"/> Min <input type="radio"/> Value of: -1500000
By Changing Cells:	\$D\$1
Subject to the Constraints:	\$I\$12 = \$I\$29

- (b) After taxes: If the tax rate of 30% is set (cell F1 in the spreadsheet below), RV = \$414,109 is obtained in D1. Therefore, after-tax consideration has, in the end, made a very small impact on the required RV value; only a \$1559 reduction.

	A	B	C	D	E	F	G	H	I
1	First cost =	(\$550,000)	RV =	\$ 414,109	Tax rate =	30%			
2			Defender						
3	Asset age	Year	P or SV	Expenses	SL depr	Current BV	TI	Taxes	CFAT
4	3	0	(414,109)			400,000			(414,109)
5	4	1		(27,000)	50,000	350,000	(77,000)	(23,100)	(3,900)
6	5	2		(27,000)	50,000	300,000	(77,000)	(23,100)	(3,900)
7	6	3		(27,000)	50,000	250,000	(77,000)	(23,100)	(3,900)
8	7	4		(27,000)	50,000	200,000	(77,000)	(23,100)	(3,900)
9	8	5		(27,000)	50,000	150,000	(77,000)	(23,100)	(3,900)
10	9	6		(27,000)	50,000	100,000	(77,000)	(23,100)	(3,900)
11	10	7	50,000	(27,000)	50,000	50,000	(77,000)	(23,100)	46,100
12	AW of CFAT @ 12%								(\$89,683)
13			Challenger						
14	P =	(\$400,000)							
15		Year	P or SV	Expenses	SL depr	BV	TI	Taxes	CFAT
16		0	(400,000)			400,000	14,109	4,233	(404,233)
17		1		(50,000)	30,417	369,583	(80,417)	(24,125)	(25,875)
18		2		(50,000)	30,417	339,167	(80,417)	(24,125)	(25,875)
19		3		(50,000)	30,417	308,750	(80,417)	(24,125)	(25,875)
20		4		(50,000)	30,417	278,333	(80,417)	(24,125)	(25,875)
21		5		(50,000)	30,417	247,917	(80,417)	(24,125)	(25,875)
22		6		(50,000)	30,417	217,500	(80,417)	(24,125)	(25,875)
23		7		(50,000)	30,417	187,083	(80,417)	(24,125)	(25,875)
24		8		(50,000)	30,417	156,667	(80,417)	(24,125)	(25,875)
25		9		(50,000)	30,417	126,250	(80,417)	(24,125)	(25,875)
26		10		(50,000)	30,417	95,833	(80,417)	(24,125)	(25,875)
27		11		(50,000)	30,417	65,417	(80,417)	(24,125)	(25,875)
28		12	35,000	(50,000)	30,417	35,000	(80,417)	(24,125)	9,125
29	AW of CAFT @ 12%								(\$89,683)

- 17.59** A finance manger likes EVA because it indicates the enhancement of a project to the monetary worth of the corporation. Engineering managers like CFAT because it indicates actual cash flow of the project.
- 17.60** A spreadsheet solution is presented. **The AW values are the same.** Note the difference in the patterns of the CFAT and EVA series. CFAT shows a big cost in year 0 and positive cash flows thereafter. EVA shows 0 in year 0 and after 2 years the value-added terms turn positive, indicating a positive contribution to the corporation's worth.

	A	B	C	D	E	F	G	H	I	J	K	L
1											Cost of	
2	Year	GI	OE	P	D	TI	Taxes	CFAT	NOPAT	BV	Inv. Capital	EVA
3	0			-300,000				-300,000		300,000		0
4	1	200,000	-80,000		99,990	20,010	7,004	112,997	13,007	200,010	-29,250	-16,244
5	2	200,000	-80,000		133,350	-13,350	-4,673	124,673	-8,678	66,660	-19,501	-28,178
6	3	200,000	-80,000		44,430	75,570	26,450	93,551	49,121	22,230	-6,499	42,621
7	4	200,000	-80,000		22,230	97,770	34,220	85,781	63,551	0	-2,167	61,383
8	AW @ 9.75%							\$11,408				\$11,407
9								=F7 - G7			= -0.0975*J6	
10											= I7 + K7	
11												
12												
13												

17.61 Depreciation is SL: Hong Kong: $4.2 \text{ million}/8 = \$525,000$
Japan: $3.6 \text{ million}/5 = \$720,000$

Hand solution is quite tedious due to the number of computations. Spreadsheet solution is easier. The CFAT series is shown, for information only. The Japan supplier indicates a larger AW of EVA, however, the difference is small given the size of the order.

	A	B	C	D	E	F	G	H	I	J	K
1											
2	Year	GI - OE	P	D	TI	NOPAT	BV	Inv Cap Cost	EVA		CFAT
3	0		-4,200,000				4,200,000				-4,200,000
4	1	1,500,000		525,000	975,000	682,500	3,675,000	-336,000	346,500		1,207,500
5	2	1,800,000		525,000	1,275,000	892,500	3,150,000	-294,000	598,500		1,417,500
6	3	2,100,000		525,000	1,575,000	1,102,500	2,625,000	-252,000	850,500		1,627,500
7	4	2,400,000		525,000	1,875,000	1,312,500	2,100,000	-210,000	1,102,500		1,837,500
8	5	2,700,000		525,000	2,175,000	1,522,500	1,575,000	-168,000	1,354,500		2,047,500
9	6	3,000,000		525,000	2,475,000	1,732,500	1,050,000	-126,000	1,606,500		2,257,500
10	7	3,300,000		525,000	2,775,000	1,942,500	525,000	-84,000	1,858,500		2,467,500
11	8	3,600,000		525,000	3,075,000	2,152,500	0	-42,000	2,110,500		2,677,500
12				4,200,000					\$1,127,328		\$1,127,328
13											
14											
15											
16	Year	GI - OE	P	D	TI	NOPAT	BV	Inv Cap Cost	EVA		CFAT
17	0		-3,600,000				3,600,000				-3,600,000
18	1	1,500,000		720,000	780,000	546,000	2,880,000	-288,000	258,000		1,266,000
19	2	1,800,000		720,000	1,080,000	756,000	2,160,000	-230,400	525,600		1,476,000
20	3	2,100,000		720,000	1,380,000	966,000	1,440,000	-172,800	793,200		1,686,000
21	4	2,400,000		720,000	1,680,000	1,176,000	720,000	-115,200	1,060,800		1,896,000
22	5	2,700,000		720,000	1,980,000	1,386,000	0	-57,600	1,328,400		2,106,000
23	6	3,000,000		0	3,000,000	2,100,000	0	0	2,100,000		2,100,000
24	7	3,300,000		0	3,300,000	2,310,000	0	0	2,310,000		2,310,000
25	8	3,600,000		0	3,600,000	2,520,000	0	0	2,520,000		2,520,000
26				3,600,000					\$1,224,312		\$1,224,312
27											
28											
29											
30											

17.62 (a) Column L shows the EVA each year. Use Equation [17.23] to calculate EVA.

(b) The $AW_{EVA} = \$382,000$ is calculated on the spreadsheet.

Note: The CFAT and AW_{CFAT} values are shown also.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	12%	= Interest	# years =	6			in \$1000						
2	30%	= Tax rate											
3		Gross	Operating					Taxable			Interest on		
4		Income	Expenses		Depr			Income			Invested		
5	Year	GI	OE	P and S	rate	D	BV	TI	Taxes	NOPAT	Capital	EVA	CFAT
6	0			-3,000			3,000						-3,000
7	1	2,700	-1,000		0.10	300	2,700	1,400	420	980	360	620	1,280
8	2	2,600	-1,050		0.20	600	2,100	950	285	665	324	341	1,265
9	3	2,500	-1,100		0.20	600	1,500	800	240	560	252	308	1,160
10	4	2,400	-1,150		0.20	600	900	650	195	455	180	275	1,055
11	5	2,300	-1,200		0.20	600	300	500	150	350	108	242	950
12	6	2,200	-1,250		0.10	300	0	650	195	455	36	419	755
13	AW											\$382	\$382
14													
15													

17.63 A sales tax is collected when the goods or services are bought by the end-user, while value-added taxes are collected at every stage of the production/distribution process.

17.64 (a) Tax collected by vendor B = $130,000(0.25) = \$32,500$

(b) Tax sent by vendor B = amount collected – amount paid to vendor A
 $= 32,500 - 60,000(0.25) = \$17,500$

(c) Amount collected by Treasury = $250,000(0.25) = \$62,500$

17.65 VAT by supplier C = $620,000(0.125)$
 $= \$77,500$

17.66 Taxes paid to supplier A = $350,000(0.04) = \$14,000$

Ajinkya kept none of the VAT due supplier A.

17.67 Taxes paid = $350(0.04) + 870(0.125) + 620(0.125) + 90(0.213) + 50(0.326)$
 $= \$235,720$

$$\begin{aligned}
17.68 \quad \text{Average VAT rate} &= \text{taxes paid}/\text{value of goods and services} \\
&= 235,720/(350 + 870 + 620 + 90 + 50) \\
&= 235,720/1980.0 \\
&= 0.1191 \quad (11.91\%)
\end{aligned}$$

$$\begin{aligned}
17.69 \quad \text{Taxes sent} &= \text{amount collected} - \text{amount paid} \\
&= 9,200,000(0.125) - 235,720 \quad (\text{from problem 17.67}) \\
&= \$914,280
\end{aligned}$$

$$\begin{aligned}
17.70 \quad \text{Taxes collected} &= \text{taxes sent by suppliers} + \text{taxes sent by Ajinkya} \\
&= 235,720 + 914,280 \\
&= \$1,150,000
\end{aligned}$$

$$\begin{aligned}
\text{or Taxes collected} &= 9,200,000(0.125) \\
&= \$1,150,000
\end{aligned}$$

17.71 Answer is (c)

17.72 Answer is (d)

$$17.73 \quad \text{Savings} = 16,000(0.35) = \$5600$$

Answer is (b)

$$17.74 \quad \text{Tax difference} = (100,000,000 - 80,000,000)(0.50) = \$10,000,000$$

Answer is (a)

17.75 Answer is (d)

17.76 Answer is (a)

$$17.77 \quad \text{Taxes} = (55,000 + 4,000 - 13,000 - 11,000) (0.25) = \$8750$$

Answer is (b)

17.78 Answer is (b)

$$\begin{aligned}
17.79 \quad \text{CFAT} &= \text{GI} - \text{OE} - \text{TI}(T_e) \\
26,000 &= 30,000 - \text{TI}(0.40) \\
\text{TI} &= (30,000 - 26,000)/0.40 = \$10,000
\end{aligned}$$

$$\text{Taxes} = \text{TI}(T_e) = 10,000(0.40) = \$4000$$

$$\begin{aligned} \text{TI} &= (\text{GI} - \text{OE} - \text{D}) \\ 10,000 &= (30,000 - \text{D}) \\ \text{D} &= \$20,000 \end{aligned}$$

Answer is (d)

$$\begin{aligned} \mathbf{17.80} \text{ Before-tax ROR} &= \text{After-tax ROR}/(1 - T_e) \\ &= 11.9\%/(1 - 0.34) \\ &= 18.0\% \end{aligned}$$

Answer is (c)

$$\mathbf{17.81} \quad \text{BV}_5 = 100,000(0.0576) = \$5760$$

$$\text{DR} = 22,000 - 5760 = \$16,240$$

$$\text{Tax on DR} = 16,240(0.30) = \$4872$$

$$\begin{aligned} \text{Cash flow} &= 22,000 - 4872 \\ &= \$17,128 \end{aligned}$$

Answer is (b)

17.82 Answer is (d)

Solution to Case Study, Chapter 17

There is not always a definitive answer to case study exercises. Here are example responses.

AFTER-TAX ANALYSIS FOR BUSINESS EXPANSION

1. The next two spreadsheets perform an analysis of the four D-E mix scenarios

	A	B	C	D	E	F	G	H	I	J	K
1			0% debt and 100% equity financing							Capital =	\$ 1,500,000
2			Debt financing (loan)	Equity	MACRS				Taxes		
3	Year	GI - E	Interest ⁽¹⁾	Principal	investment	rate	Depr.	TI	@ 35%	CFAT	
4	0				(\$1,500,000)	-				(\$1,500,000)	
5	1	\$600,000	\$0	\$0		0.2000	\$300,000	\$300,000	\$105,000	\$495,000	
6	2	\$600,000	\$0	\$0		0.3200	\$480,000	\$120,000	\$42,000	\$558,000	
7	3	\$600,000	\$0	\$0		0.1920	\$288,000	\$312,000	\$109,200	\$490,800	
8	4	\$600,000	\$0	\$0		0.1152	\$172,800	\$427,200	\$149,520	\$450,480	
9	5	\$600,000	\$0	\$0		0.1152	\$172,800	\$427,200	\$149,520	\$450,480	
10	6	\$600,000			\$0	0.0576	\$86,400	\$513,600	\$179,760	\$420,240	
11	Totals					1.0000	\$1,500,000		\$735,000	\$1,365,000	
12	Pw at 10%									\$604,513	
13	(1) Interest plus principal = \$ debt/5 + (\$ debt)/(0.06)										
14			50% debt and 50% equity financing								
15			Debt financing (loan)	Equity	MACRS				Taxes		
16	Year	GI - E	Interest ⁽¹⁾	Principal	investment	rate	Depr.	TI	@ 35%	CFAT	
17	0				(\$750,000)	-				(\$750,000)	
18	1	\$600,000	(\$45,000)	(\$150,000)		0.2000	\$300,000	\$255,000	\$89,250	\$315,750	
19	2	\$600,000	(\$45,000)	(\$150,000)		0.3200	\$480,000	\$75,000	\$26,250	\$378,750	
20	3	\$600,000	(\$45,000)	(\$150,000)		0.1920	\$288,000	\$267,000	\$93,450	\$311,550	
21	4	\$600,000	(\$45,000)	(\$150,000)		0.1152	\$172,800	\$382,200	\$133,770	\$271,230	
22	5	\$600,000	(\$45,000)	(\$150,000)		0.1152	\$172,800	\$382,200	\$133,770	\$271,230	
23	6	\$600,000			\$0	0.0576	\$86,400	\$513,600	\$179,760	\$420,240	
24	Totals					1.0000	\$1,500,000		\$656,250	\$1,218,750	
25	Pw at 10%									\$675,015	
26											
27											
28			There are three worksheets for this case study solution								

	A	B	C	D	E	F	G	H	I	J	K
1			70% debt and 30% equity financing							Capital =	\$ 1,500,000
2			Debt financing (loan)	Equity	MACRS				Taxes		
3	Year	GI - E	Interest	Principal	investment	rate	Depr.	TI	@ 35%	CFAT	
4	0				(\$450,000)	-				(\$450,000)	
5	1	\$600,000	(\$63,000)	(\$210,000)		0.2000	\$300,000	\$237,000	\$82,950	\$244,050	
6	2	\$600,000	(\$63,000)	(\$210,000)		0.3200	\$480,000	\$57,000	\$19,950	\$307,050	
7	3	\$600,000	(\$63,000)	(\$210,000)		0.1920	\$288,000	\$249,000	\$87,150	\$239,850	
8	4	\$600,000	(\$63,000)	(\$210,000)		0.1152	\$172,800	\$364,200	\$127,470	\$199,530	
9	5	\$600,000	(\$63,000)	(\$210,000)		0.1152	\$172,800	\$364,200	\$127,470	\$199,530	
10	6	\$600,000			\$0	0.0576	\$86,400	\$513,600	\$179,760	\$420,240	
11	Totals					1.0000	\$1,500,000		\$624,750	\$1,160,250	
12	Pw at 10%									\$703,215	
13											
14											
15			90% debt and 10% equity financing								
16			Debt financing (loan)	Equity	MACRS				Taxes		
17	Year	GI - E	Interest	Principal	investment	rate	Depr.	TI	@ 35%	CFAT	
18	0				(\$150,000)	-				(\$150,000)	
19	1	\$600,000	(\$81,000)	(\$270,000)		0.2000	\$300,000	\$219,000	\$76,650	\$172,350	
20	2	\$600,000	(\$81,000)	(\$270,000)		0.3200	\$480,000	\$39,000	\$13,650	\$235,350	
21	3	\$600,000	(\$81,000)	(\$270,000)		0.1920	\$288,000	\$231,000	\$80,850	\$168,150	
22	4	\$600,000	(\$81,000)	(\$270,000)		0.1152	\$172,800	\$346,200	\$121,170	\$127,830	
23	5	\$600,000	(\$81,000)	(\$270,000)		0.1152	\$172,800	\$346,200	\$121,170	\$127,830	
24	6	\$600,000			\$0	0.0576	\$86,400	\$513,600	\$179,760	\$420,240	
25	Totals					1.0000	\$1,500,000		\$593,250	\$1,101,750	
26	Pw at 10%									\$731,416	

Note: Column B, E used instead of OE for operating expenses.

Conclusion: The 90% debt option has the largest PW at 10%. As mentioned in the chapter, the largest D-E financing option will always offer the largest return on the invested equity capital. But, too high of D-E mixes are risky.

2. Subtract 2 different equity CFAT totals.

For 30% and 10%:

$$(1,160,250 - 1,101,750) = \$58,500$$

Divide by 2 to get the change per 10% equity increase.

$$58,500/2 = \$29,250$$

Conclusion: Total CFAT increases by \$29,250 for each 10% increase in equity financing.

3. This happens because as less of Pro-Fence's own (equity) funds are committed to the Victoria site, the larger the loan principal.

4. Use the EVA series as an estimate of contribution to Pr-Fence's bottom line through time.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Exercise #4) EVA for 50%-50% financing												
2			50% debt and 50% equity financing					Capital = \$ 1,500,000				Interest on	
3			Debt financing (loan)		Equity	MACRS		Book value		Taxes		invested	
4	Year	Gl - E	Interest ⁽¹⁾	Principal	investment	rate	Depr.	BV	TI	@ 35%	NPAT	capital ⁽¹⁾	EVA
5	0				(\$750,000)	.		\$ 1,500,000					
6	1	\$600,000	(\$45,000)	(\$150,000)		0.2000	\$300,000	\$ 1,200,000	\$255,000	\$89,250	\$165,750	\$150,000	\$15,750
7	2	\$600,000	(\$45,000)	(\$150,000)		0.3200	\$480,000	\$ 720,000	\$75,000	\$26,250	\$48,750	\$120,000	(\$71,250)
8	3	\$600,000	(\$45,000)	(\$150,000)		0.1920	\$288,000	\$ 432,000	\$267,000	\$93,450	\$173,550	\$72,000	\$101,550
9	4	\$600,000	(\$45,000)	(\$150,000)		0.1152	\$172,800	\$ 259,200	\$382,200	\$133,770	\$248,430	\$43,200	\$205,230
10	5	\$600,000	(\$45,000)	(\$150,000)		0.1152	\$172,800	\$ 86,400	\$382,200	\$133,770	\$248,430	\$25,920	\$222,510
11	6	\$600,000			\$0	0.0576	\$86,400	\$ -	\$513,600	\$179,760	\$333,840	\$8,640	\$325,200
12	Totals					1.0000	\$1,500,000			\$656,250			
13	PW at 10%												\$493,633
14	AW @ 10%												\$113,342
15													
16	(1) Interest at 10% is calculated on the basis of \$1.5 million, not the smaller amount of equity capital committed.												

Equations used to determine the EVA use NOPAT (or NPAT) and interest on invested capital.

$$\text{EVA} = \text{NPAT} - \text{interest on invested capital} \quad (\text{column M})$$

$$\text{NPAT} = \text{TI} - \text{taxes}$$

$$\begin{aligned} (\text{Interest on invested capital})_t &= i(\text{BV in the previous year}) \\ &= 0.10(\text{BV}_{t-1}) \end{aligned}$$

Note: BV on the entire \$1.5 million in depreciable assets is used to determine the interest on invested capital.

Conclusion: The added business in Victoria should turn positive the third year and remain a contributor to the business after that, as indicated by the EVA values. Plus, the AW of EVA at the required 10% return is positive ($AW = \$113,342$).

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 18
Sensitivity Analysis and Staged Decisions

18.1 \$135,000: $PW = -500,000 + 135,000(P/A, 15\%, 5)$
 $= -500,000 + 135,000(3.3522)$
 $= \$-47,453 \quad (ROR < 15\%)$

\$165,000: $PW = -500,000 + 165,000(P/A, 15\%, 5)$
 $= -500,000 + 165,000(3.3522)$
 $= \$53,113 \quad (ROR > 15\%)$

The decision to invest *is sensitive* to the revenue estimates

18.2 Start family now: $FW = 50,000(F/A, 10\%, 5)(F/P, 10\%, 20) + 15,000(F/A, 10\%, 20)$
 $= 50,000(6.1051)(6.7275) + 15,000(57.2750)$
 $= \$2,912,728 \quad (> \$2,600,000)$

Their retirement goal is not sensitive to when they start their family.

18.3 Invest now: $FW = -80,000(F/P, 20\%, 6) + 25,000(F/A, 20\%, 6)$
 $= -80,000(2.9860) + 25,000(9.9299)$
 $= \$9368 \quad (> 20\% \text{ per year})$

Invest 1-year from now: $FW = -80,000(F/P, 20\%, 5) + 26,000(F/A, 20\%, 5)$
 $= -80,000(2.4883) + 26,000(7.4416)$
 $= \$-5582 \quad (< 20\% \text{ per year})$

Invest 2-years from now: $FW = -80,000(F/P, 20\%, 4) + 29,000(F/A, 20\%, 4)$
 $= -80,000(2.0736) + 29,000(5.3680)$
 $= \$-10,216 \quad (< 20\% \text{ per year})$

The timing will affect whether the company earns its MARR; *invest now*.

18.4 Low pressure: $A = 465 + 0.67(3,000,000/1000) = \2475 per day

High pressure, X: $A = 328 + 1.35(3,000,000/1000) = \4378

High pressure, Y: $A = 328 + 1.28(3,000,000/1000) = \4168

The low pressure system is the best option.

18.5 $AW_{\text{current}} = \$-63,000$

$$\begin{aligned} AW_{10,000} &= -64,000(A/P, 15\%, 3) - 38,000 + 10,000(A/F, 15\%, 3) \\ &= -64,000(0.43798) - 38,000 + 10,000(0.28798) \\ &= \$-63,151 \end{aligned}$$

$$\begin{aligned} AW_{13,000} &= -64,000(A/P, 15\%, 3) - 38,000 + 13,000(A/F, 15\%, 3) \\ &= -64,000(0.43798) - 38,000 + 13,000(0.28798) \\ &= \$-62,287 \end{aligned}$$

$$\begin{aligned} AW_{18,000} &= -64,000(A/P, 15\%, 3) - 38,000 + 18,000(A/F, 15\%, 3) \\ &= -64,000(0.43798) - 38,000 + 18,000(0.28798) \\ &= \$-60,847 \end{aligned}$$

The decision *is sensitive* to the salvage value estimates. If the salvage value will be \$13,000 or \$18,000, the company should replace the existing machine. Otherwise, keep the current one.

18.6 Joe: $PW = -77,000 + 10,000(P/F, 8\%, 6) + 10,000(P/A, 8\%, 6)$
 $= -77,000 + 10,000(0.6302) + 10,000(4.6229)$
 $= \$-24,469$

Jane: $PW = -77,000 + 10,000(P/F, 8\%, 6) + 14,000(P/A, 8\%, 6)$
 $= -77,000 + 10,000(0.6302) + 14,000(4.6229)$
 $= \$-5,977$

Carlos: $PW = -77,000 + 10,000(P/F, 8\%, 6) + 18,000(P/A, 8\%, 6)$
 $= -77,000 + 10,000(0.6302) + 18,000(4.6229)$
 $= \$12,514$

Only the \$18,000 revenue estimate (Carlos) favors the investment.

18.7 $AW_{\text{Cnt}} = \$-175,000$

$$\begin{aligned} AW_{\text{High}} &= -250,000(A/P, 15\%, 3) - 75,000 + 90,000(A/F, 15\%, 3) \\ &= -250,000(0.43798) - 75,000 + 90,000(0.28798) \\ &= \$-158,577 \quad (< \$-175,000) \end{aligned}$$

$$\begin{aligned} AW_{\text{Low}} &= -250,000(A/P, 15\%, 3) - 75,000 + 10,000(A/F, 15\%, 3) \\ &= -250,000(0.43798) - 75,000 + 10,000(0.28798) \\ &= \$-181,615 \quad (> \$-175,000) \end{aligned}$$

Decision *is sensitive* to salvage value.

18.8 Required AW < \$5.7 million

$$\begin{aligned} 10\%: AW &= -10,500,000(A/P, 10\%, 5) - 3,100,000 + 2,000,000(A/F, 10\%, 5) \\ &= -10,500,000(0.26380) - 3,100,000 + 2,000,000(0.16380) \\ &= \$-5,542,300 \quad (< \$-5,700,000) \end{aligned}$$

$$\begin{aligned} 12\%: AW &= -10,500,000(A/P, 12\%, 5) - 3,100,000 + 2,500,000(A/F, 12\%, 5) \\ &= -10,500,000(0.27741) - 3,100,000 + 2,500,000(0.15741) \\ &= \$-5,619,280 \quad (< \$-5,700,000) \end{aligned}$$

The decision is *not sensitive* since both AW values are below \$5.7 million.

18.9 $AW_{\text{Cont}} = -130,000(A/P, 15\%, 5) - 30,000 + 40,000(A/F, 15\%, 5)$
 $= -130,000(0.29832) - 30,000 + 40,000(0.14832)$
 $= \$-62,849$

The lowest cost for the batch operation will occur when the interest rate is the lowest (i.e., 5%) and the life is longest (i.e., 10 years)

$$\begin{aligned} AW_{\text{Batch}} &= -80,000(A/P, 5\%, 10) - 55,000 + 10,000(A/F, 5\%, 10) \\ &= -80,000(0.12950) - 55,000 + 10,000(0.07950) \\ &= \$-64,565 \quad (> \$-62,849) \end{aligned}$$

The batch system will never be less expensive than continuous flow

18.10 (a) $Q = FC/(70-40) = FC/30$

FC, \$	Q_{BE} , units
200,000	6667
250,000	8333
300,000	10,000
350,000	11,667
400,000	13,333

(b) The change in Q_{BE} is 1667 units for each \$50,000 increase in FC.

18.11
$$\begin{aligned} PW &= -P + (60,000 - 5000)(P/A, 10\%, 5) \\ &= -P + 55,000(3.7908) \\ &= -P + 208,494 \end{aligned}$$

Percent variation	P value, \$	PW, \$
-25%	-150,000	58,494
-20	-160,000	48,494
-10	-180,000	28,494
0	-200,000	8,494
10	220,000	-11,506
20	240,000	-31,506
25	250,000	-41,506

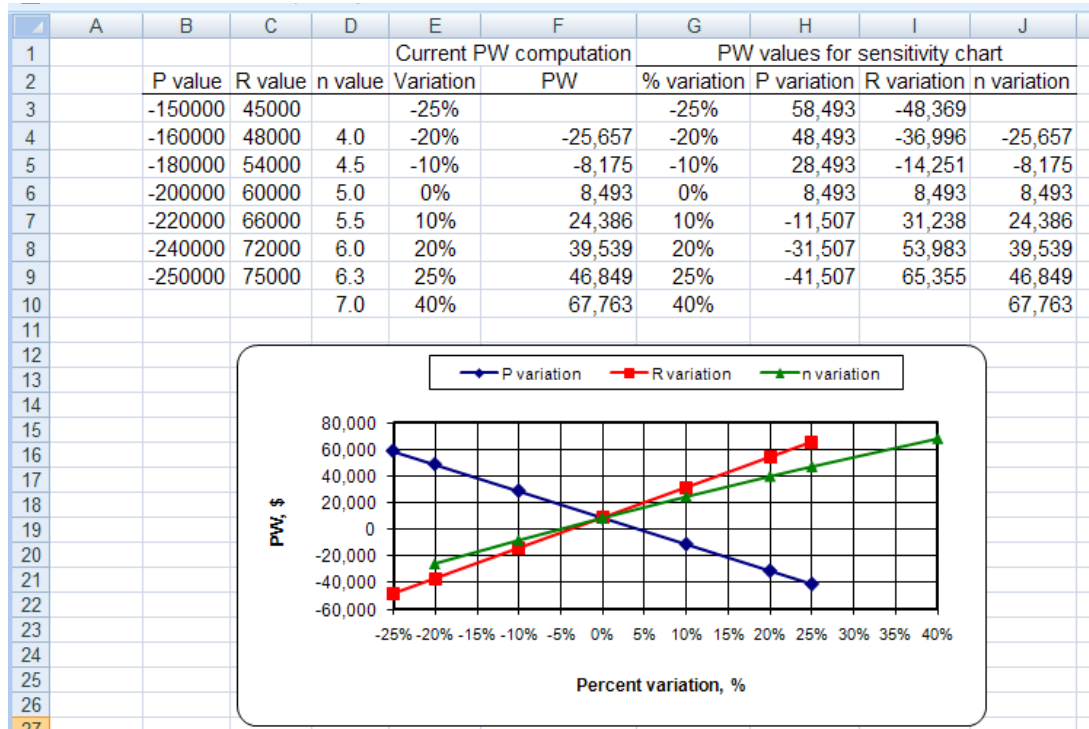
18.12
$$\begin{aligned} PW &= -200,000 + R(P/A, 10\%, 5) - 5000(P/A, 10\%, 5) \\ &= -200,000 + R(3.7908) - 5000(3.7908) \\ &= -218,954 + 3.7908R \end{aligned}$$

Percent variation	R value, \$	PW, \$
-25%	45,000	-48,368
-20	48,000	-36,996
-10	54,000	-14,251
0	60,000	8,494
10	66,000	31,239
20	72,000	53,984
25	75,000	65,356

18.13
$$PW = -200,000 + (60,000 - 5000)((P/A, 10\%, n))$$

Percent variation	n value	PW, \$
-20%	4.0	-25,656
-10	4.5	-8,175
0	5.0	8,494
10	5.5	24,386
20	6.0	39,541
25	6.5	46,849
40	7.0	67,762

18.14 Spreadsheet is plotted for all three parameters: P, R and n. Variations in P and R have about the same effect on PW in opposite directions, and more effect than variation in n.



18.15 Set up the F relation in 20 years, consider this a P value, and calculate the withdrawals at $A = P(i)$ forever. Let A = annual deposit and R = annual withdrawal after year 20

$$\begin{aligned} \text{Future worth of deposits: } F &= A(F/A, i, n) = 27,185(F/A, 6\%, 20) \\ &= 27,185(36.7856) \\ &= \$1,000,016 \end{aligned}$$

$$\begin{aligned} \text{Withdrawals: } R &= F(i) = 1,000,016(0.06) \\ &= \$60,000 \text{ per year forever} \end{aligned}$$

Hand solution

(a) $R = A(F/A, 6\%, 20)(i) = A(36.7856)(0.06)$

Percent variation	A, annual deposit, \$	R, \$ per year
-5%	25,826	57,000
0	27,185	60,000
5%	28,544	63,000

(b) $R = 27,185(F/A, i, 20)(i)$

Return value	Percent variation	R, \$ per year
5%	-16.7%	44,945
6%	0	60,000
7%	16.7%	78,012

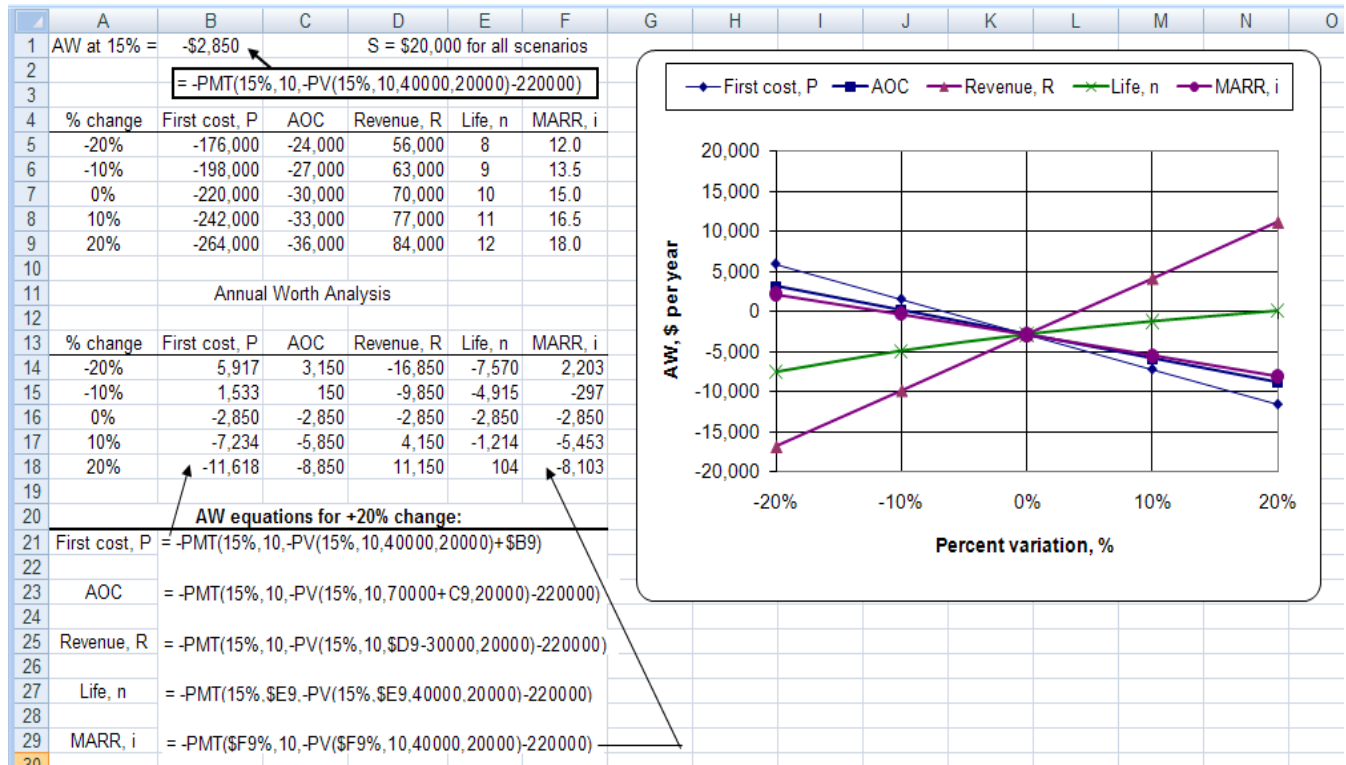
The amount available for annual withdrawal is much more sensitive to i than to A .

Spreadsheet solution

	A	B	C	D	E	F	G
1	Deposit	Variation	Deposit	FV	Withdrawal		
2	variation	-5%	-25,826	950,015	\$ 57,001		
3		0%	-27,185	1,000,016	\$ 60,001		
4		5%	-28,544	1,050,017	\$ 63,001		
5				= FV(6%,20,C4)			
6							
7	Earning	Variation	Rate	FV	Withdrawal		
8	rate	-16.7%	5%	898,898	\$ 44,945		
9	variation	0%	6%	1,000,016	\$ 60,001		
10		16.7%	7%	1,114,462	\$ 78,012	= C10*D10	

18.16 Spreadsheet for -20% to +20% changes in P, AOC, R, n and MARR follows. The PMT function for a +20% change is detailed at the bottom of the spreadsheet.

AW is most sensitive to variations in revenue R and least sensitive to variations in life n.



18.17 Determine AW values at different savings, s.

$$\begin{aligned}
 AW_A &= -50,000(A/P, 10\%, 5) - 7500 + 5,000(A/F, 10\%, 5) + s \\
 &= -50,000(0.2638) - 7500 + 5000(0.1638) + s \\
 &= -19,871 + s
 \end{aligned}$$

$$\begin{aligned}
 AW_B &= -37,500(A/P, 10\%, 5) - 8000 + 3700(A/F, 10\%, 5) + s \\
 &= -37,500(0.2638) - 8000 + 3700(0.1638) + s \\
 &= -17,286 + s
 \end{aligned}$$

Percent variation	Savings for A, \$ per year	AW _A	Savings for B, \$ per year	AW _B	Selection
-40%	9,000	\$-10,871	7,800	\$-9,486	B
-20	12,000	-7,871	10,400	-6,886	B
0	15,000	-4,871	13,000	-4,286	B
20	18,000	-1,871	15,600	-1,686	B
40	21,000	1,129	18,200	914	A

Selection changes when s = +40% of best estimate. Spreadsheet solution follows.

	A	B	C	D	E	F	G
1	Percent	Company A		Company B			
2	variation	Revenue	AW	Revenue	AW	Selection	
3	-40%	9,000	-10,871	7,800	-9,486	B	
4	-20%	12,000	-7,871	10,400	-6,886	B	
5	0%	15,000	-4,871	13,000	-4,286	B	
6	20%	18,000	-1,871	15,600	-1,686	B	
7	40%	21,000	1,129	18,200	914	A	
8							
9		= -PMT(10%,5,-50000,5000)-7500+B7		= -PMT(10%,5,-37500,3700)-8000+D7			
10							

18.18 (a) PW calculates the amount you should be willing to pay now. Plot PW versus $\pm 30\%$ changes in (a), (b) and (c) on one graph.

(1) Face value, V

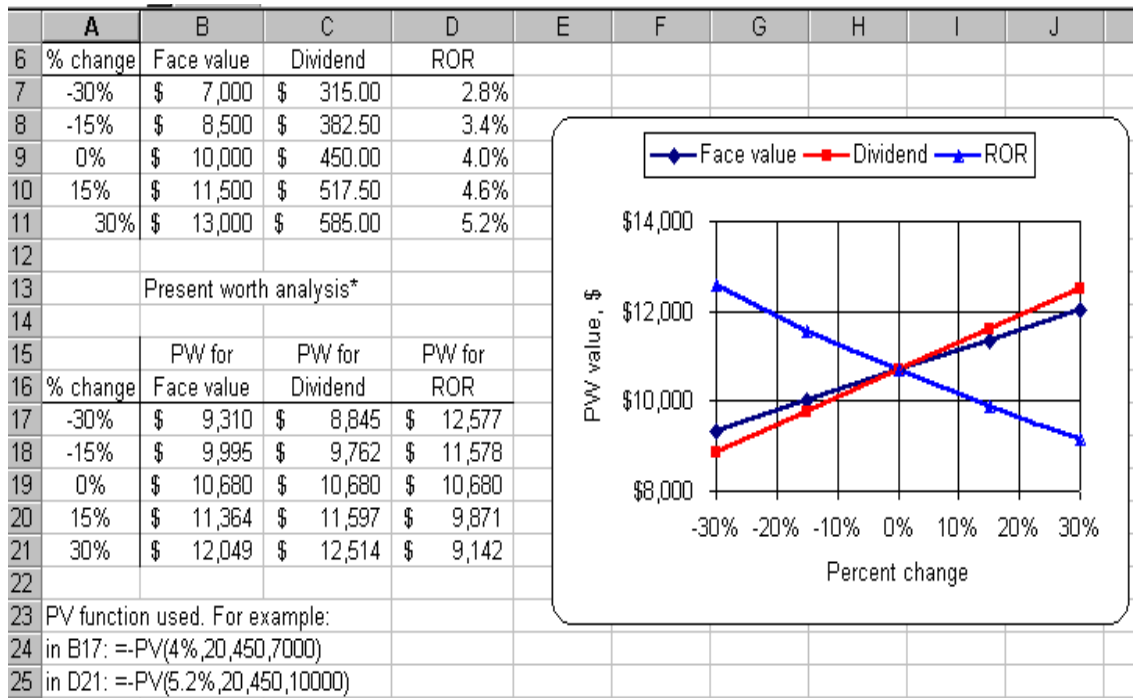
$$\begin{aligned} PW &= V(P/F, 4\%, 20) + 450(P/A, 4\%, 20) \\ &= V(0.4564) + 6116 \end{aligned}$$

(2) Dividend rate, b

$$\begin{aligned} PW &= 10,000(P/F, 4\%, 20) + (10,000/2)(b)(P/A, 4\%, 20) \\ &= 10,000(0.4564) + b(5000)(13.5903) \\ &= 4564 + b(67,952) \end{aligned}$$

(3) Nominal rate, r

$$PW = 10,000(P/F, r, 20) + 450(P/A, r, 20)$$



(b) Amount paid is $10,000(1.05) = \$10,500$

For 0% change, $PW = \$10,680$. Therefore, \$180 less was paid than the investor was willing to pay to make a nominal 8% per year, compounded semiannually.

18.19 $AW_{\text{Contract}} = \$-190,000$

$$\begin{aligned}
 AW_{\text{Optimistic}} &= -240,000(A/P, 20\%, 5) - 60,000 + 30,000(A/F, 20\%, 5) \\
 &= -240,000(0.33438) - 60,000 + 30,000(0.13438) \\
 &= \$-136,220 \quad (< \$-190,000; \text{purchase equipment})
 \end{aligned}$$

$$\begin{aligned}
 AW_{\text{Most Likely}} &= -240,000(A/P, 20\%, 5) - 85,000 + 30,000(A/F, 20\%, 5) \\
 &= -240,000(0.33438) - 85,000 + 30,000(0.13438) \\
 &= \$-161,220 \quad (< \$-190,000; \text{purchase equipment})
 \end{aligned}$$

$$\begin{aligned}
 AW_{\text{Pessimistic}} &= -240,000(A/P, 20\%, 5) - 120,000 + 30,000(A/F, 20\%, 5) \\
 &= -240,000(0.33438) - 120,000 + 30,000(0.13438) \\
 &= \$-196,220 \quad (> \$-190,000; \text{do not purchase equipment})
 \end{aligned}$$

The optimistic and most likely estimates favor purchasing the equipment, but the pessimistic estimate does not.

18.20 $AW_{\text{Lease}} = \$-30,000 \text{ per year}$

$$\begin{aligned} AW_{\text{Pessimistic}} &= -880,000(A/P, 10\%, 20) + 900,000(A/F, 10\%, 20) \\ &= -880,000(0.11746) + 900,000(0.01746) \\ &= \$-87,651 \end{aligned}$$

$$\begin{aligned} AW_{\text{Most Likely}} &= -880,000(A/P, 10\%, 20) + 1,400,000(A/F, 10\%, 20) \\ &= -880,000(0.11746) + 1,400,000(0.01746) \\ &= \$-78,920 \end{aligned}$$

$$\begin{aligned} AW_{\text{Optimistic}} &= -880,000(A/P, 10\%, 20) + 2,400,000(A/F, 10\%, 20) \\ &= -880,000(0.11746) + 2,400,000(0.01746) \\ &= \$-61,461 \end{aligned}$$

It would not be cost-effective to purchase the building under any resale-value scenario

18.21
$$\begin{aligned} AW_{490G} &= -250,000(A/P, 10\%, 2) - 3000 + 25,000(A/F, 10\%, 2) \\ &= -250,000(0.57619) - 3000 + 25,000(0.47619) \\ &= \$-135,143 \end{aligned}$$

$$\begin{aligned} AW_{D103 \text{ 2-year life}} &= -400,000(A/P, 10\%, 2) - 4000 + 40,000(A/F, 10\%, 2) \\ &= -400,000(0.57619) - 4000 + 40,000(0.47619) \\ &= \$-215,428 \quad (> \$-135,143) \end{aligned}$$

$$\begin{aligned} AW_{D103 \text{ 3-year life}} &= -400,000(A/P, 10\%, 3) - 4000 + 40,000(A/F, 10\%, 3) \\ &= -400,000(0.40211) - 4000 + 40,000(0.30211) \\ &= \$-152,760 \quad (> \$-135,143) \end{aligned}$$

$$\begin{aligned} AW_{D103 \text{ 6-year life}} &= -400,000(A/P, 10\%, 6) - 4000 + 40,000(A/F, 10\%, 6) \\ &= -400,000(0.22961) - 4000 + 40,000(0.12961) \\ &= \$-90,660 \quad (< \$-135,143) \end{aligned}$$

The D103 chamber would be more cost-effective than the G490 only under the optimistic life estimate of 6 years.

18.22 (a) MARR = 8% (Pessimistic)

$$\begin{aligned} PW_M &= -100,000 + 15,000(P/A, 8\%, 20) \\ &= -100,000 + 15,000(9.8181) \\ &= \$47,272 \end{aligned}$$

$$\begin{aligned} PW_Q &= -110,000 + 19,000(P/A, 8\%, 20) \\ &= -110,000 + 19,000(9.8181) \\ &= \$76,544 \end{aligned}$$

MARR = 10% (Most Likely)

$$\begin{aligned}PW_M &= -100,000 + 15,000(P/A, 10\%, 20) \\ &= -100,000 + 15,000(8.5136) \\ &= \$27,704\end{aligned}$$

$$\begin{aligned}PW_Q &= -110,000 + 19,000(P/A, 10\%, 20) \\ &= -110,000 + 19,000(8.5136) \\ &= \$51,758\end{aligned}$$

MARR = 15% (Optimistic)

$$\begin{aligned}PW_M &= -100,000 + 15,000(P/A, 15\%, 20) \\ &= -100,000 + 15,000(6.2593) \\ &= \$-6111\end{aligned}$$

$$\begin{aligned}PW_Q &= -110,000 + 19,000(P/A, 15\%, 20) \\ &= -110,000 + 19,000(6.2593) \\ &= \$8927\end{aligned}$$

(b) n = 16: Expanding economy (Optimistic)

$$n = 20(0.80) = 16 \text{ years}$$

$$\begin{aligned}PW_M &= -100,000 + 15,000(P/A, 10\%, 16) \\ &= -100,000 + 15,000(7.8237) \\ &= \$17,356\end{aligned}$$

$$\begin{aligned}PW_Q &= -110,000 + 19,000(P/A, 10\%, 16) \\ &= -110,000 + 19,000(7.8237) \\ &= \$38,650\end{aligned}$$

n = 20: Expected economy (Most likely)

$$PW_M = \$27,704 \quad (\text{From part (a)})$$

$$PW_Q = \$51,758 \quad (\text{From part (a)})$$

n = 22: Receding economy (Pessimistic)

$$n = 20(1.10) = 22 \text{ years}$$

$$\begin{aligned}PW_M &= -100,000 + 15,000(P/A, 10\%, 22) \\ &= -100,000 + 15,000(8.7715) \\ &= \$31,573\end{aligned}$$

$$\begin{aligned}
 PW_Q &= -110,000 + 19,000(P/A, 10\%, 22) \\
 &= -110,000 + 19,000(8.7715) \\
 &= \$56,659
 \end{aligned}$$

- (c) Observing the PW values, plan M always has a lower PW value, so it is not accepted and plan Q is.

$$\begin{aligned}
 \mathbf{18.23} \quad E(X) &= 600,000(0.20) + 800,000(0.50) + 900,000(0.30) \\
 &= \$790,000
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{18.24} \quad E(X) &= 20,000(0.32) + 28,000(0.45) + 34,000(0.13) + 0.10(-5,000) \\
 &= \$22,920
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{18.25} \quad E(X) &= (0.13)[1,500,000 + 1,900,000 + 2,400,000]/3 \\
 &= \$251,333
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{18.26} \quad E(X) &= 1/12[500,000(4) + 600,000(2) + 700,000(1) + 800,000(2) + 900,000(3)] \\
 &= 8,200,000/12 \\
 &= \$683,333
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{18.27} \quad E(X) &= 3(0.4) + 4(0.3) + 5(0.2) + 6(0.1) \\
 &= 4.0
 \end{aligned}$$

$$\mathbf{18.28} \quad (a) \quad E(\text{cycle time}) = (1/4)(10 + 20 + 30 + 50) = 27.5 \text{ seconds}$$

$$(b) \quad E(\text{cycle time}) = (1/3)(10 + 20 + 30) = 20 \text{ seconds}$$

$$\begin{aligned}
 \% \text{ reduction} &= (27.5 - 20)/27.5 \\
 &= 27.3\%
 \end{aligned}$$

$$\mathbf{18.29} \quad \text{Solve for } PW_{\text{high}} \text{ from } E(PW)$$

$$\begin{aligned}
 E(PW) &= 5875 = 3200(0.3) + (PW_{\text{high}})(0.7) \\
 PW_{\text{high}} &= \$7021
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{18.30} \quad E(i) &= 1/20[(-8)(1) + (-5)(1) + 0(5) + \dots + 15(3)] \\
 &= 103/20 \\
 &= 5.15\%
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{18.31} \quad E(FW) &= 0.20(300,000 - 25,000) + 0.6(50,000) \\
 &= \$85,000
 \end{aligned}$$

18.32 Determine E(AW) after calculating E(revenue).

$$\begin{aligned}
 E(\text{revenue}) &= [\text{days}](\text{climbers})(\text{income/climber})(\text{probability}) \\
 &= [(120)(350)(5)](0.3) + [(120)(350)(5) + 30(100)(5)](0.5) \\
 &\quad + [(120)(350)(5) + (45)(100)(5)](0.2) \\
 &= 63,000 + 112,500 + 46,500 \\
 &= \$222,000
 \end{aligned}$$

$$\begin{aligned}
 E(AW) &= -375,000(A/P, 12\%, 10) - 25,000[(P/F, 12\%, 4) + (P/F, 12\%, 8)] \\
 &\quad \times (A/P, 12\%, 10) - 56,000 + 222,000 \\
 &= -375,000(0.17698) - 25,000[(0.6355) + (0.4039)](0.17698) + 166,000 \\
 &= \$95,034
 \end{aligned}$$

The mock mountain should be constructed.

18.33 Determine E(PW) after calculating the PW of E(revenue)

$$E(\text{revenue}) = P(\text{slump})(\text{revenue over 3-year periods})$$

$$\begin{aligned}
 PW[E(\text{revenue})] &= PW[P(\text{slump})(\text{revenue 1}^{\text{st}} \text{ 3 years}) \\
 &\quad + P(\text{slump})(\text{revenue 2}^{\text{nd}} \text{ 3 years}) \\
 &\quad + P(\text{expansion})(\text{revenue 1}^{\text{st}} \text{ 3 years}) \\
 &\quad + P(\text{expansion})(\text{revenue 2}^{\text{nd}} \text{ 3 years})] \\
 &= 0.5[20,000(P/A, 8\%, 3)] + 0.2[20,000(P/A, 8\%, 3) \\
 &\quad \times (P/F, 8\%, 3)] + 0.5[35,000(P/A, 8\%, 3)] \\
 &\quad + 0.8[35,000(P/A, 8\%, 3)(P/F, 8\%, 3)] \\
 &= 0.5[51,542] + 0.2 [40,914] + 0.5 [90,198] + 0.8 [71,600] \\
 &= \$136,333
 \end{aligned}$$

$$\begin{aligned}
 E(PW) &= -200,000 + 200,000(0.12) (P/F, 8\%, 6) + PW[E(\text{revenue})] \\
 &= -200,000 + 15,125 + 136,333 \\
 &= \$-48,542
 \end{aligned}$$

No, less than an 8% return is expected.

18.34 $AW = \text{annual loan payment} + (\text{damage}) \times P(\text{rainfall amount or greater})$

Subscript on AW indicates rainfall amount.

$$\begin{aligned}
 AW_{2.0} &= -200,000(A/P, 6\%, 10) + (-50,000)(0.3) \\
 &= -200,000(0.13587) - 50,000(0.3) \\
 &= \$-42,174
 \end{aligned}$$

$$\begin{aligned}
 AW_{2.25} &= -225,000(A/P, 6\%, 10) + (-50,000)(0.1) \\
 &= -300,000(0.13587) - 50,000(0.1) \\
 &= \$-35,571
 \end{aligned}$$

$$\begin{aligned}
 AW_{2.5} &= -300,000(A/P, 6\%, 10) + (-50,000)(0.05) \\
 &= -350,000(0.13587) - 50,000(0.05) \\
 &= \$-43,261
 \end{aligned}$$

$$\begin{aligned}
 AW_{3.0} &= -400,000(A/P, 6\%, 10) + (-50,000)(0.01) \\
 &= -400,000(0.13587) - 50,000(0.01) \\
 &= \$-54,848
 \end{aligned}$$

$$\begin{aligned}
 AW_{3.25} &= -450,000(A/P, 6\%, 10) + (-50,000)(0.005) \\
 &= -450,000(0.13587) - 50,000(0.005) \\
 &= \$-61,392
 \end{aligned}$$

Build a wall to protect against a rainfall of 2.25 inches with an expected
 $AW = \$-35,571$.

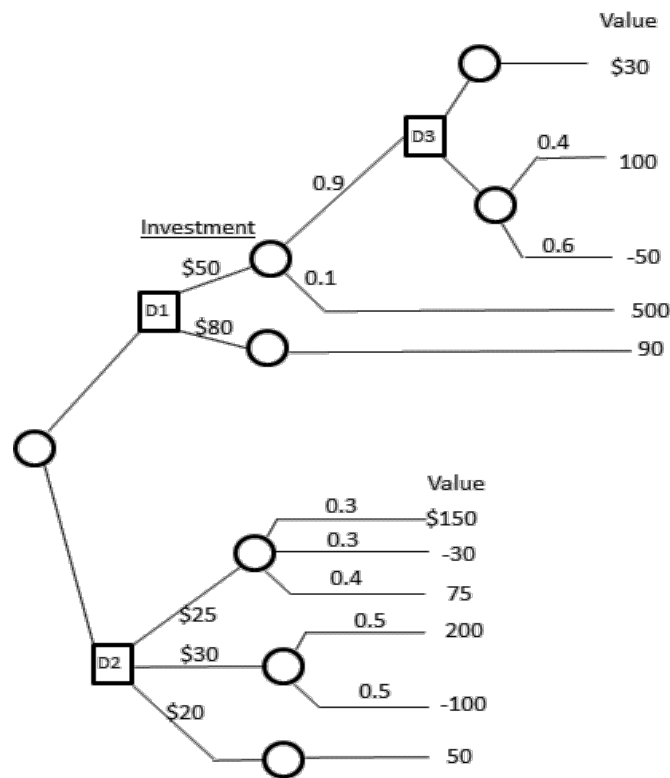
18.35 Compute the expected value for each outcome and select the maximum for D3.

$$\text{Top node: } 0.4(55) + 0.30(-30) + 0.30(10) = 16.0$$

$$\text{Bottom node: } 0.6(-17) + 0.4(0) = -10.2$$

Indicate 16.0 and -10.2 in ovals and select the top branch with $E(\text{value}) = 16.0$.

18.36



Maximize the value at each decision node.

D3: Top: $E(\text{value}) = \$30$
 Bottom: $E(\text{value}) = 0.4(100) + 0.6(-50) = \10

Select top at D3 for \$30

D1: Top: $0.9(\text{D3 value}) + 0.1(\text{final value})$
 $0.9(30) + 0.1(500) = \$77$

At D1, value = $E(\text{value}) - \text{investment}$

Top: $77 - 50 = \$27$ (maximum)
 Bottom: $90 - 80 = \$10$

Select top at D1 for \$27

D2: Top: $E(\text{value}) = 0.3(150 - 30) + 0.4(75) = \66
 Middle: $E(\text{value}) = 0.5(200 - 100) = \50
 Bottom: $E(\text{value}) = \$50$

At D2, value = E(value) – investment

Top: $66 - 25 = \$41$ (maximum)

Middle: $50 - 30 = \$20$

Bottom: $50 - 20 = \$30$

Select top at D2 for \$41

Conclusion: Select D2 path and choose top branch (\$25 investment)

18.37 Calculate the E(PW) in year 3 and select the largest expected value. In \$1000 units,

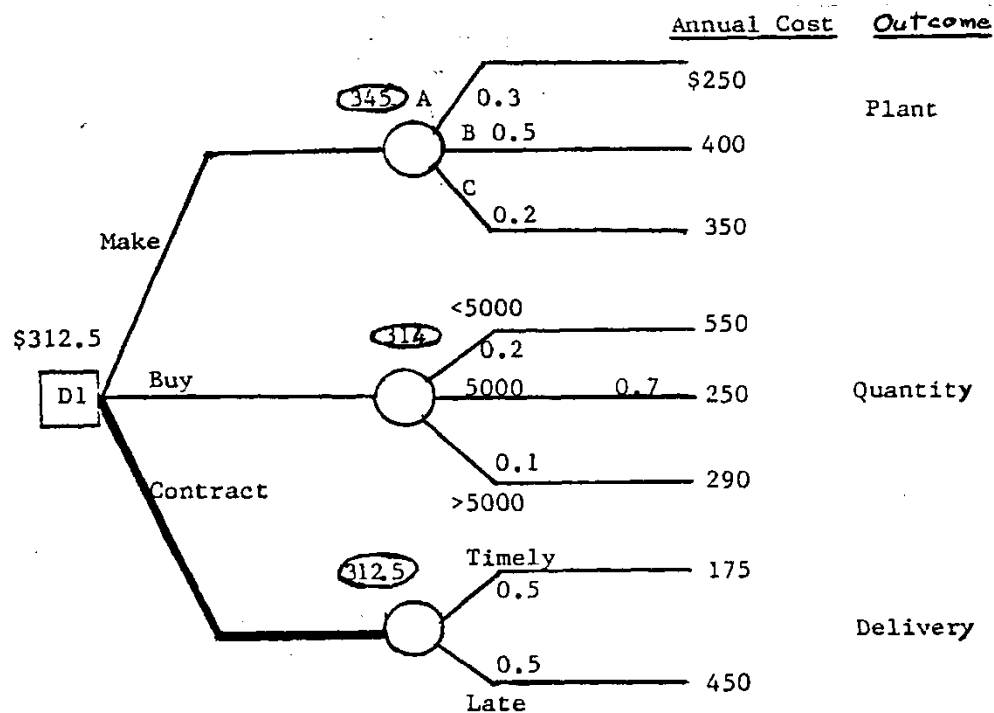
$$\begin{aligned} E(\text{PW of D4,x}) &= -200 + 0.7[50(P/A,15\%,3)] + 0.3[40(P/F,15\%,1) \\ &\quad + 30(P/F,15\%,2) + 20(P/F,15\%,3)] \\ &= -98.903 \quad (\$-98,903) \end{aligned}$$

$$\begin{aligned} E(\text{PW of D4,y}) &= -75 + 0.45[30(P/A,15\%,3) + 10(P/G,15\%,3)] \\ &\quad + 0.55[30(P/A,15\%,3)] \\ &= 2.816 \quad (\$2816) \end{aligned}$$

$$\begin{aligned} E(\text{PW of D4,z}) &= -350 + 0.7[190(P/A,15\%,3) - 20(P/G,15\%,3)] \\ &\quad + 0.3[-30(P/A,15\%,3)] \\ &= -95.880 \quad (\$-95,880) \end{aligned}$$

Select decision branch y; it has the largest E(PW)

18.38 Select the minimum E(cost) alternative. All monetary units are times \$-1000.



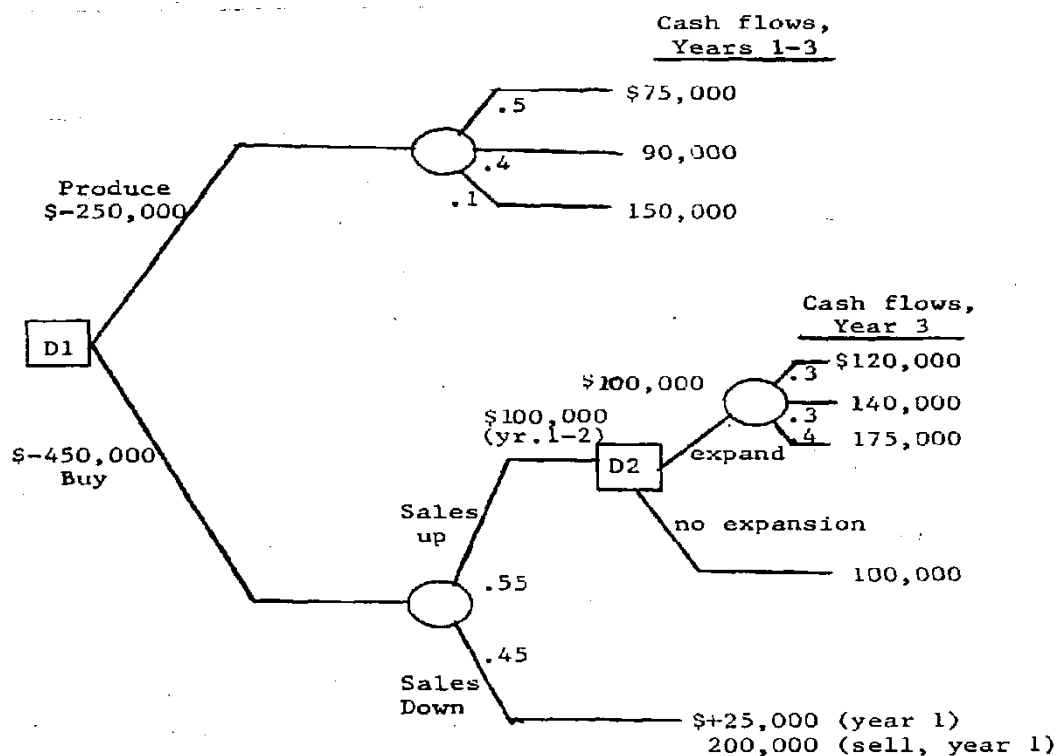
Make: $E(\text{cost of plant}) = 0.3(250) + 0.5(400) + 0.2(350)$
 $= \$345$ (\$345,000)

Buy: $E(\text{cost of quantity}) = 0.2(550) + 0.7(250) + 0.1(290)$
 $= \$314$ (\$314,000)

Contract: $E(\text{cost of delivery}) = 0.5(175 + 450)$
 $= \$312.5$ (\$312,500)

Select the contract alternative since the E(cost of delivery) is the lowest at \$312,500.

18.39 (a) Construct the decision tree.



(b) At D2 compute PW of cash flows and E(PW) using probability values.

Expansion option

$$\begin{aligned} (\text{PW for D2, } \$120,000) &= -100,000 + 120,000(P/F, 15\%, 1) \\ &= \$4352 \end{aligned}$$

$$\begin{aligned} (\text{PW for D2, } \$140,000) &= -100,000 + 140,000(P/F, 15\%, 1) \\ &= \$21,744 \end{aligned}$$

$$(\text{PW for D2, } \$175,000) = \$52,180$$

$$E(\text{PW}) = 0.3(4352 + 21,744) + 0.4(52,180) = \$28,700$$

No expansion option

$$\begin{aligned} (\text{PW for D2, } \$100,000) &= \$100,000(P/F, 15\%, 1) = \$86,960 \\ E(\text{PW}) &= \$86,960 \end{aligned}$$

Conclusion at D2: Select no expansion option

- (c) Complete rollback to D1 considering 3 year cash flow estimates.

Produce option, D1

$$\begin{aligned} E(\text{PW of cash flows}) &= [0.5(75,000) + 0.4(90,000) + 0.1(150,000)](P/A, 15\%, 3) \\ &= \$202,063 \end{aligned}$$

$$\begin{aligned} E(\text{PW for produce}) &= \text{cost} + E(\text{PW of cash flows}) \\ &= -250,000 + 202,063 \\ &= \$-47,937 \end{aligned}$$

Buy option, D1

$$\text{At D2, } E(\text{PW}) = \$86,960$$

$$\begin{aligned} E(\text{PW for buy}) &= \text{cost} + E(\text{PW of sales cash flows}) \\ &= -450,000 + 0.55(\text{PW sales up}) + 0.45(\text{PW sales down}) \end{aligned}$$

$$\begin{aligned} \text{PW Sales up} &= 100,000(P/A, 15\%, 2) + 86,960(P/F, 15\%, 2) \\ &= \$228,320 \end{aligned}$$

$$\begin{aligned} \text{PW sales down} &= (25,000 + 200,000)(P/F, 15\%, 1) \\ &= \$195,660 \end{aligned}$$

$$\begin{aligned} E(\text{PW for buy}) &= -450,000 + 0.55(228,320) + 0.45(195,660) \\ &= \$-236,377 \end{aligned}$$

Conclusion: $E(\text{PW for produce})$ is larger than $E(\text{PW for buy})$; select produce option.

Note: The returns are both less than 15%, but the return is larger for produce option.

- (d) The return would increase on the initial investment, but would increase faster for the produce option.

$$\begin{aligned} \mathbf{18.40} \quad \text{In \$ billion units,} \quad \text{PW}_{\text{option}} &= 3 - 3.1(P/F, 12\%, 1) \\ &= 3 - 3.1(0.8929) \\ &= \$0.232 \quad (\$232 \text{ million}) \end{aligned}$$

18.41 In \$ million units,

$$\begin{aligned} \text{PW}_{\text{Invest now}} &= -80 + [35(0.333) + 25(0.333) + 10(0.333)](P/A, 12\%, 5) \\ &= -80 + [35(0.333) + 25(0.333) + 10(0.333)](3.6048) \\ &= \$4.028 \quad (\$4.028 \text{ million}) \end{aligned}$$

$$\begin{aligned}
PW_{\text{Invest later}} &= -4 + 0.9(P/F, 12\%, 1) - 80(P/F, 12\%, 1) + [35(0.5) + 25(0.5)] \\
&\quad \times (P/A, 12\%, 4)(P/F, 12\%, 1) \\
&= -4 + 0.9(0.8929) - 80(0.8929) + [35(0.5) + 25(0.5)](3.0373)(0.8929) \\
&= \$6.732 \quad (\$6.732 \text{ million})
\end{aligned}$$

If the test is not successful, that is, revenue does not exceed \$900,000, $PW < 0$.

Conclusion: Company should implement the test program option and delay the full-scale decision for 1 year.

$$\begin{aligned}
\mathbf{18.42} \quad PW_{\text{Now}} &= -1,800,000 + 1,000,000(0.75)(P/A, 15\%, 5) \\
&= -1,800,000 + 1,000,000(0.75)(3.3522) \\
&= \$714,150
\end{aligned}$$

$$\begin{aligned}
PW_{1 \text{ year}} &= -150,000 - 1,900,000(P/F, 15\%, 1) + 1,000,000(0.70)(P/A, 15\%, 5)(P/F, 15\%, 1) \\
&= -150,000 - 1,900,000(0.8696) + 1,000,000(0.70)(3.3522)(0.8696) \\
&= \$238,311
\end{aligned}$$

The company should license the process now

18.43 (a) Find $E(PW)$ after determining $E(R_t)$, the expected repair costs for each year t

$$E(R_2) = 1/3(-500 - 1000 - 0) = \$-500$$

$$E(R_3) = 1/3(-1200 - 1400 - 500) = \$-1033$$

$$E(R_4) = 1/3(-850 - 400 - 2000) = \$-1083$$

$$\begin{aligned}
E(PW) &= -500(P/F, 5\%, 2) - 1033(P/F, 5\%, 3) - 1083(P/F, 5\%, 4) \\
&= -500(0.9070) - 1033(0.8638) - 1083(0.8227) \\
&= \$-2237
\end{aligned}$$

Not considering any noneconomic factors, the warranty is worth an expected \$2237, or \$263 less than the option price.

$$\begin{aligned}
\text{(b) } PW_{\text{base}} &= -500(P/F, 5\%, 3) - 2000(P/F, 5\%, 4) \\
&= -500(0.8638) - 2000(0.8227) \\
&= \$-2077
\end{aligned}$$

18.44 Answer is (b)

18.45 Answer is (a)

18.46 Answer is (c)

$$\begin{aligned} \mathbf{18.47} \quad E(AW) &= 30,000(0.2) + 40,000(0.2) + 50,000(0.6) \\ &= \$44,000 \end{aligned}$$

Answer is (c)

$$\begin{aligned} \mathbf{18.48} \quad AW_{\text{Optimistic}} &= -90,000(A/P, 10\%, 5) - 29,000 + 15,000(A/F, 10\%, 5) \\ &= -90,000(0.26380) - 29,000 + 15,000(0.16380) \\ &= \$-50,285 \quad (> \$-48,000) \end{aligned}$$

Therefore, none of the salvage values will result in an $AW < \$-48,000$

Answer is (d)

18.49 Answer is (d)

18.50 Answer is (c)

$$\begin{aligned} \mathbf{18.51} \quad PW &= 70,000 - 70,000(P/F, 10\%, 1) \\ &= 70,000 - 70,000(0.9091) \\ &= \$6363 \end{aligned}$$

Answer is (b)

Solutions to Case Studies, Chapter 18

Sometimes, there is not a definitive answer to a case study exercise. Here are example responses.

SENSITIVITY TO THE ECONOMIC ENVIRONMENT

1. Spreadsheet analysis used for changes in MARR. *PW is not very sensitive*; plan A is selected for all three MARR values.

	A	B	C	D
1	Plan A, NCF, \$	Plan B, NCF, \$		
2	-10,000	-35,000		
3	-500	-300		
4	-500	-300		
5	-500	-300		
22	-500	-5,500		
23	-500	-300		
24	-500	-300		
40	-500	-300		
41	-500	-300		
42	500	4,500		
43	PW of A, \$	PW of B, \$	MARR	
44	-19,688	-42,311	4%	
45	-16,599	-40,023	7%	
46	-14,867	-38,601	10%	

Not all years shown

2. Sensitivity to changes in life is performed by hand. *Not very sensitive*; plan A has the best PW for all life estimates.

Expanding economy

$$n_A = 40(0.80) = 32 \text{ years}$$

$$n_1 = 40(0.80) = 32 \text{ years}$$

$$n_2 = 20(0.80) = 16 \text{ years}$$

$$\begin{aligned} PW_A &= -10,000 + 1000(P/F, 10\%, 32) - 500(P/A, 10\%, 32) \\ &= -10,000 + 1,000(0.0474) - 500(9.5264) \\ &= \$-14,716 \end{aligned}$$

$$\begin{aligned} PW_B &= -30,000 + 5000(P/F, 10\%, 32) - 100(P/A, 10\%, 32) - 5000 \\ &\quad - 200(P/F, 10\%, 16) - 5000(P/F, 10\%, 16) - 200(P/F, 10\%, 32) \\ &\quad - 200(P/A, 10\%, 32) \\ &= -35,000 + 4800(P/F, 10\%, 32) - 300(P/A, 10\%, 32) - 5200(P/F, 10\%, 16) \\ &= -35,000 + 4800(0.0474) - 300(9.5264) - 5200(0.2176) \\ &= \$-38,762 \end{aligned}$$

Expected economy

$$\begin{aligned}PW_A &= -10,000 + 1000(P/F, 10\%, 40) - 500(P/A, 10\%, 40) \\&= -10,000 + 1000(0.0221) - 500(9.7791) \\&= \$-14,867\end{aligned}$$

$$\begin{aligned}PW_B &= -30,000 + 5000(P/F, 10\%, 40) - 100(P/A, 10\%, 40) - 5000 \\&\quad - 200(P/F, 10\%, 20) - 5000(P/F, 10\%, 20) - 200(P/F, 10\%, 40) \\&\quad - 200(P/A, 10\%, 40) \\&= -35,000 + 4800(P/F, 10\%, 40) - 300(P/A, 10\%, 40) - 5200(P/F, 10\%, 20) \\&= -35,000 + 4800(0.0221) - 300(9.7791) - 5200(0.1486) \\&= \$-38,600\end{aligned}$$

Receding economy

$$\begin{aligned}n_A &= 40(1.10) = 44 \text{ years} \\n_1 &= 40(1.10) = 44 \text{ years} \\n_2 &= 20(1.10) = 22 \text{ years}\end{aligned}$$

$$\begin{aligned}PW_A &= -10,000 + 1000(P/F, 10\%, 44) - 500(P/A, 10\%, 44) \\&= -10,000 + 1000(0.0154) - 500(9.8461) \\&= \$-14,908\end{aligned}$$

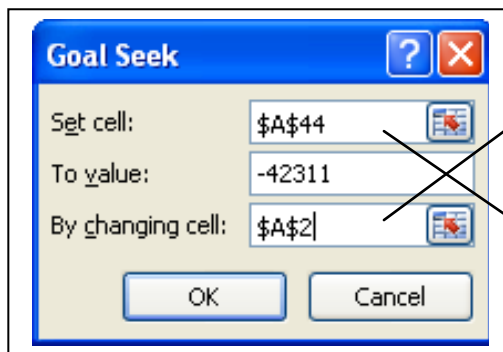
$$\begin{aligned}PW_B &= -30,000 + 5000(P/F, 10\%, 44) - 100(P/A, 10\%, 44) - 5000 \\&\quad - 200(P/F, 10\%, 22) - 5000(P/F, 10\%, 22) - 200(P/F, 10\%, 44) \\&\quad - 200(P/A, 10\%, 44) \\&= -35,000 + 4800(P/F, 10\%, 44) - 300(P/A, 10\%, 44) - 5200(P/F, 10\%, 22) \\&= -35,000 + 4800(0.0154) - 300(9.8461) - 5200(0.1228) \\&= \$-38,519\end{aligned}$$

- Use Goal Seek to find the breakeven values of P_A for the three MARR values of 4%, 7%, and 10% per year.

For MARR = 4%, the Goal Seek screen is below. Breakeven values are:

MARR	Breakeven P_A
4%	\$-32,623
7	-33,424
10	-33,734

The P_A breakeven value is *not sensitive*, but all three outcomes are over 3X the \$10,000 estimated first cost for plan A.



	A	B	C
1	Plan A, NCF, \$	Plan B, NCF, \$	
2	-32,623	-35,000	
3	-500	-300	
4	-500	-300	
5	-500	-300	
22	-500	-5,500	
23	-500	-300	
24	-500	-300	
40	-500	-300	
41	-500	-300	
42	500	4,500	
43	PW of A, \$	PW of B, \$	MARR
44	-42,311	-42,311	4%
45	-39,222	-40,023	7%
46	-37,490	-38,601	10%

Solutions to Case Studies, Chapter 18

Sometimes, there is not a definitive answer to a case study exercise. Here are example responses.

SENSITIVITY ANALYSIS OF PUBLIC SECTOR PROJECTS -- WATER SUPPLY PLANS

1. Let x = weighting per factor

Since there are 6 factors and one (environmental considerations) is to have a weighting that is double the others, its weighting is $2x$. Thus,

$$\begin{aligned} 2x + x + x + x + x + x &= 100 \\ 7x &= 100 \\ x &= 14.3\% \end{aligned}$$

Therefore, the environmental weighting is $2(14.3)$, or 28.6%

- 2.

Alt ID	Ability to Supply Area	Relative Cost	Engineering Feasibility	Institutional Issues	Environmental Considerations	Lead-Time Requirement	Total
1A	5(0.2)	4(0.2)	3(0.15)	4(0.15)	5(0.15)	3(0.15)	4.1
3	5(0.2)	4(0.2)	4(0.15)	3(0.15)	4(0.15)	3(0.15)	3.9
4	4(0.2)	4(0.2)	3(0.15)	3(0.15)	4(0.15)	3(0.15)	3.6
8	1(0.2)	2(0.2)	1(0.15)	1(0.15)	3(0.15)	4(0.15)	2.0
12	5(0.2)	5(0.2)	4(0.15)	1(0.15)	3(0.15)	1(0.15)	3.4

The top three are the same as before: 1A, 3, and 4

3. For alternative 4 to be as economically attractive as alternative 3, its total annual cost would have to be the same as that of alternative 3, which is \$3,881,879. Thus, if P_4 is the capital investment,

$$\begin{aligned} 3,881,879 &= P_4(A/P, 8\%, 20) + 1,063,449 \\ 3,881,879 &= P_4(0.10185) + 1,063,449 \\ P_4 &= \$27,672,361 \end{aligned}$$

$$\begin{aligned} \text{Decrease} &= 29,000,000 - 27,672,361 \\ &= \$1,327,639 \text{ or } 4.58\% \end{aligned}$$

4. Household cost at 100% = $3,952,959(1/12)(1/4980)(1/1)$
= \$66.15

$$\begin{aligned} \text{Decrease} &= 69.63 - 66.15 \\ &= \$3.48 \text{ or } 5\% \end{aligned}$$

5. (a) Sensitivity analysis of M&O and number of households.

Alternative	Estimate	M&O, \$/year	Number of households	Total annual cost, \$/year	Household cost, \$/month
1A	Pessimistic	1,071,023	4980	3,963,563	69.82
	Most likely	1,060,419	5080	3,952,959	68.25
	Optimistic	1,049,815	5230	3,942,355	66.12
3	Pessimistic	910,475	4980	3,925,235	69.40
	Most likely	867,119	5080	3,881,879	67.03
	Optimistic	867,119	5230	3,881,879	65.10
4	Pessimistic	1,084,718	4980	4,038,368	71.13
	Most likely	1,063,449	5080	4,017,099	69.37
	Optimistic	957,104	5230	3,910,754	65.59

Conclusion: Alternative 3 - optimistic is the best.

(b) Let x be the number of households. Set alternative 4 - optimistic cost equal to \$65.10.

$$(3,910,754)/12(0.95)(x) = \$65.10$$

$$x = 5270$$

This is an increase of only 40 households.

Solutions to end-of-chapter problems
Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

Chapter 19
More on Variation and Decision Making Under Risk

- 19.1** (a) Continuous
(b) Discrete
(c) Discrete
(d) Continuous
(e) Continuous

- 19.2** (a) Discrete and Certainty
(b) Discrete and Risk
(c) Continuous and Uncertain
(d) Discrete and Uncertain
(e) Continuous and Risk

- 19.3** Needed or assumed information to calculate an expected value:
1. Treat output as discrete or continuous variable.
 2. If discrete, center points on cells, e.g., 800, 1500, and 2200 units per week.
 3. Probability estimates for < 1000 and /or > 2000 units per week.

19.4 (a) $E(RI) = 6200(0.10) + 8500(0.21) + 9600(0.32) + 10,300(0.24) + 12,600(0.09) + 15,500(0.04)$
 $= \$9703$

(b) $P(RI \geq 12,600) = P(RI = 12,600) + P(RI = 15,500)$
 $= 0.09 + 0.04$
 $= 0.13$

- 19.5** (a) Frequency distribution is as follows

<u>Cell boundaries</u>	<u>Frequencies</u>
19.5 - 31.5	4
31.5 - 43.5	10
43.5 - 55.5	8
55.5 - 67.5	6
67.5 - 79.5	3

(b) Probability distribution is as follows

<u>Cell Boundaries</u>	<u>Frequencies</u>	<u>Probability</u>
19.5 - 31.5	4	0.13
31.5 - 43.5	10	0.32
43.5 - 55.5	8	0.26
55.5 - 67.5	6	0.19
67.5 - 79.5	3	0.10

$$(c) P(\$ < 44) = 0.32 + 0.13 \\ = 0.45$$

$$(d) P(\$ \geq 44) = 0.26 + 0.19 + 0.10 \\ = 0.55$$

19.6 (a) N is discrete since only specific values are mentioned; i is continuous from 0 to 12.

(b) Plot the probability and cumulative probability values for N and i calculated below.

<u>N</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	
P(N)	.12	.56	.26	.03	.03	
F(N)	.12	.68	.94	.97	1.00	
<u>i</u>	<u>0-2</u>	<u>2-4</u>	<u>4-6</u>	<u>6-8</u>	<u>8-10</u>	<u>10-12</u>
P(i)	.13	.14	.19	.38	.12	.04
F(i)	.13	.27	.46	.84	.96	1.00

$$(c) P(N = 1 \text{ or } 2) = P(N = 1) + P(N = 2) \\ = 0.56 + 0.26 = 0.82 \\ \text{or} \\ F(N \leq 2) - F(N \leq 0) = 0.94 - 0.12 = 0.82$$

$$P(N \geq 3) = P(N = 3) + P(N \geq 4) = 0.06$$

$$(d) P(7\% \leq i \leq 11\%) = P(6.01 \leq i \leq 12.0) \\ = 0.38 + 0.12 + 0.04 = 0.54 \\ \text{or} \\ F(i \leq 12\%) - F(i \leq 6\%) = 1.00 - 0.46 \\ = 0.54$$

19.7 (a)

<u>\$</u>	<u>0</u>	<u>2</u>	<u>5</u>	<u>10</u>	<u>100</u>
F(\$)	.91	.955	.98	.993	1.000

The variable \$ is discrete, so plot \$ versus F(\$).

$$\begin{aligned}
 \text{(b)} \quad E(\$) &= \sum \$P(\$) = 0.91(0) + \dots + 0.007(100) \\
 &= 0 + 0.09 + 0.125 + 0.13 + 0.7 \\
 &= \$1.045
 \end{aligned}$$

$$\text{(c)} \quad 2.000 - 1.045 = \$0.955$$

Long-term income is 95.5¢ per ticket

$$\mathbf{19.8} \quad \text{(a)} \quad P(N) = (0.5)^N \quad N = 1, 2, 3, \dots$$

N	1	2	3	4	5	etc.
P(N)	0.5	0.25	0.125	0.0625	0.03125	
F(N)	0.5	0.75	0.875	0.9375	0.96875	

Plot P(N) and F(N); N is discrete.

P(L) is triangular like the distribution in Figure 19-5 with the mode at 5.

$$f(\text{mode}) = f(M) = \frac{2}{5-2} = \frac{2}{3}$$

$$F(\text{mode}) = F(M) = \frac{5-2}{5-2} = 1$$

$$\text{(b)} \quad P(N = 1, 2 \text{ or } 3) = F(N \leq 3) = 0.875$$

19.9 First cost, P

P_P = first cost to purchase

P_L = first cost to lease

Use the uniform distribution relations in Equation [19.3] and plot.

$$f(P_P) = 1/(25,000 - 20,000) = 0.0002$$

$$f(P_L) = 1/(2000 - 1800) = 0.005$$

Salvage value, S

S_P is triangular with mode at \$2500.

The $f(S_P)$ is symmetric around \$2500.

$$f(M) = f(2500) = 2/(1000) = 0.002 \text{ is the probability at } \$2500.$$

There is no S_L distribution

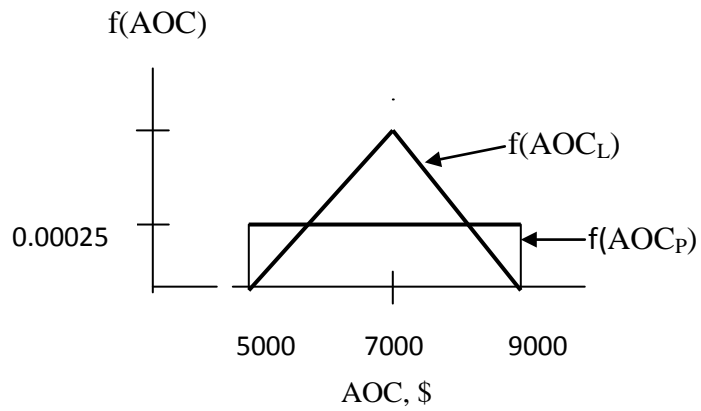
AOC

AOC_P is uniform with:

$$f(\text{AOC}_P) = 1/(9000-5000) = 0.00025$$

f(AOC_L) is triangular with:

$$f(7000) = 2/(9000-5000) = 0.0005$$

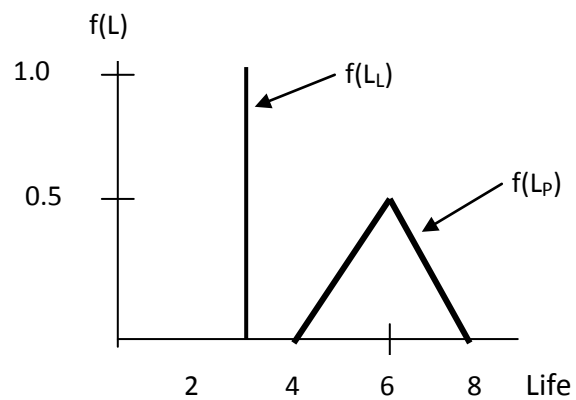


Life, L

f(L_P) is triangular with mode at 6:

$$f(6) = 2/(8-4) = 0.5$$

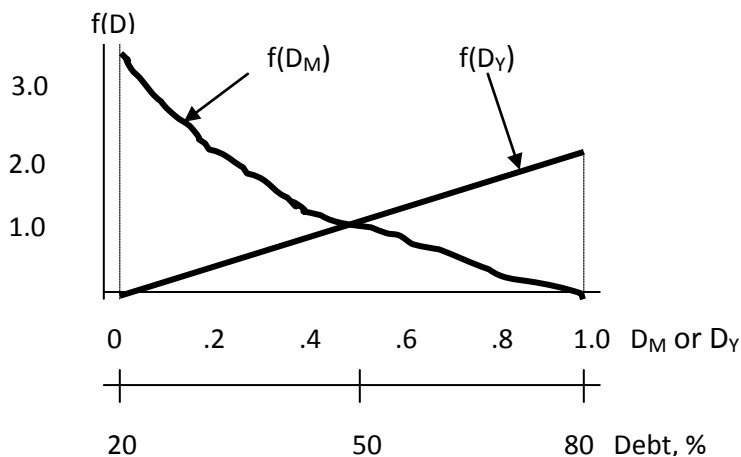
The value L_L is certain at 3 years.



19.10 (a) Determine several values of D_M and D_Y and plot.

D_M or D_Y	$f(D_M)$	$f(D_Y)$
0.0	3.00	0.0
0.2	1.92	0.4
0.4	1.08	0.8
0.6	0.48	1.2
0.8	0.12	1.6
1.0	0.00	2.0

$f(D_M)$ is a decreasing power curve and $f(D_Y)$ is linear.



(b) Probability is larger that M (mature) companies have a lower debt percentage and that Y (young) companies have a higher debt percentage.

19.11 (a)

X_i	1	2	3	6	9	10
$F(X_i)$	0.2	0.4	0.6	0.7	0.9	1.0

(b) $P(6 \leq X \leq 10) = F(10) - F(3) = 1.0 - 0.6 = 0.4$

or

$P(X = 6, 9 \text{ or } 10) = 0.1 + 0.2 + 0.1 = 0.4$

$P(X = 4, 5 \text{ or } 6) = F(6) - F(3) = 0.7 - 0.6 = 0.1$

(c) $P(X = 7 \text{ or } 8) = F(8) - F(6) = 0.7 - 0.7 = 0.0$

No sample values in the 50 have $X = 7$ or 8 . A larger sample is needed to observe all values of X .

19.12 (a) Sample size is $n = 25$

Variable value	1	2	3	4	5
Assigned Numbers	0 - 19	20 - 49	50 - 59	60 - 89	90 - 99
Times in sample	4	10	1	8	2
Sample probability	0.16	0.40	0.04	0.32	0.08

(b) $P(X = 1) = 0.16$ Stated $P(X = 1) = 0.20$
 $P(X = 5) = 0.08$ Stated $P(X = 5) = 0.10$

19.13 (a)

X	0	.2	.4	.6	.8	1.0
F(X)	0	.04	.16	.36	.64	1.00

Take X and p values from the graph. Some samples are:

RN	X	p
18	.42	7.10%
59	.76	8.80
31	.57	7.85
29	.52	7.60

(b) Use the sample mean for the average p value. Our sample of 30 had $p = 6.3375\%$; yours will vary depending on the RNs from Table 19.2.

19.14 Use the steps in Section 19.3. As an illustration, assume the probabilities that are assigned by a student are:

$$P(G = g) = \begin{bmatrix} 0.30 & G = A \\ 0.40 & G = B \\ 0.20 & G = C \\ 0.10 & G = D \\ 0.00 & G = F \\ 0.00 & G = I \end{bmatrix}$$

Steps 1 and 2: The F(G) and RN assignment are:

$$F(G = g) = \begin{bmatrix} 0.30 & G = A & \text{RNs} \\ 0.70 & G = B & 00-29 \\ 0.90 & G = C & 30-69 \\ 1.00 & G = D & 70-89 \\ 1.00 & G = F & 90-99 \\ 1.00 & G = I & -- \end{bmatrix}$$

Steps 3 and 4: Develop a scheme for selecting the RNs from Table 19-2. Assume you want 25 values. For example, if $RN_1 = 39$, the value of G is B. Repeat for sample of 25 grades.

Step 5: Count the number of grades A through D, calculate the probability of each as count/25, and plot the probability distribution for grades A through I. Compare these probabilities with $P(G = g)$ above.

19.15 (a) When the RAND() function was used for 100 values in column A of a spreadsheet, the function = AVERAGE(A1:A100) resulted in 0.50750658; very close to 0.5.

(b) For the RAND results, count the number of values in each cell to determine how close it is to 10.

19.16 (a) $\bar{X} = (81, 86, 80, 91, 83, 83, 96, 85, 89)/9$
 $= 86$

(b) Reading	Mean, \bar{X}	$X_i - \bar{X}$	$(X_i - \bar{X})^2$
81	86	-5	25
86	86	0	0
80	86	-6	36
91	86	5	25
83	86	-3	9
83	86	-3	9
96	86	10	100
85	86	-1	1
<u>89</u>	<u>86</u>	<u>3</u>	<u>9</u>
774	86	0	214

$$s = \sqrt{214/(9-1)}$$

$$= 5.17$$

(c) Range for $\pm 1s$ is $86 \pm 5.17 = 80.83 - 91.17$

Number of values in range = 7

% of values in range = $7/9 = 77.8\%$

19.17 (a) *Hand solution* Use Equations [19.9] and [19.12].

Cell, X_i	f_i	X_i^2	$f_i X_i$	$f_i X_i^2$
600	6	360,000	3,600	2,160,000
800	10	640,000	8,000	6,400,000
1000	7	1,000,000	7,000	7,000,000
1200	15	1,440,000	18,000	21,600,000
1400	28	1,960,000	39,200	54,880,000
1600	15	2,560,000	24,000	38,400,000
1800	9	3,240,000	16,200	29,160,000
2000	<u>10</u>	<u>4,000,000</u>	<u>20,000</u>	<u>40,000,000</u>
	100		136,000	199,600,000

Sample mean: $\bar{X} = 136,000/100 = 1360.00$

Std deviation:
$$s = \left[\frac{199,600,000}{99} - \frac{100}{99} (1360)^2 \right]^{1/2}$$

$$= (147,878.79)^{1/2}$$

$$= 384.55$$

(b) $\bar{X} \pm 2s$ is $1360.00 \pm 2(384.55) = 590.90$ and 2129.10

All values are in the $\pm 2s$ range.

(c) Plot X versus f . Indicate \bar{X} and the range $\bar{X} \pm 2s$ on it.

(d) Use SUMPRODUCT and SUM functions to obtain average for frequency data.

	A	B	C	D	E	F	G
1	X	f					
2	600	6					
3	800	10					
4	1000	7					
5	1200	15					
6	1400	28					
7	1600	15					
8	1800	9					
9	2000	10					
10							
11	Mean	1360	=SUMPRODUCT(A2:A9,B2:B9)/SUM(B2:B9)				
12							

19.18 (a) Convert P(X) data to frequency values to determine s.

X	P(X)	XP(X)	f	X ²	fX ²
1	.2	.2	10	1	10
2	.2	.4	10	4	40
3	.2	.6	10	9	90
6	.1	.6	5	36	180
9	.2	1.8	10	81	810
10	.1	<u>1.0</u>	5	100	<u>500</u>
		4.6			1630

Sample average: $\bar{X} = 4.6$

Sample variance: $s^2 = \frac{1630}{49} - \frac{50}{49} (4.6)^2 = 11.67$

Std deviation $s = (11.67)^{0.5} = 3.42$

(b) $\bar{X} \pm 1s$ is $4.6 \pm 3.42 = 1.18$ and 8.02

25 values, or 50%, are in this range.

$\bar{X} \pm 2s$ is $4.6 \pm 6.84 = -2.24$ and 11.44

All 50 values, or 100%, are in this range.

19.19 (a) Use Equations [19.15] and [19.16]. Substitute Y for D_Y.

$$f(Y) = 2Y$$

$$\begin{aligned} E(Y) &= \int_0^1 (Y) 2Y dy \\ &= \left[\frac{2Y^3}{3} \right]_0^1 \end{aligned}$$

$$= 2/3 - 0 = 2/3$$

$$\begin{aligned} \text{Var}(Y) &= \int_0^1 (Y^2) 2Y dy - [E(Y)]^2 \\ &= \left[\frac{2Y^4}{4} \right]_0^1 - (2/3)^2 \end{aligned}$$

$$= \frac{2}{4} - 0 - \frac{4}{9}$$

$$= 1/18 = 0.05556$$

$$\sigma = (0.05556)^{0.5} = 0.236$$

(b) $E(Y) \pm 2\sigma$ is $0.667 \pm 0.472 = 0.195$ and 1.139

Take the integral from 0.195 to 1.0 since the variable's upper limit is 1.0.

$$\begin{aligned} P(0.195 \leq Y \leq 1.0) &= \int_{0.195}^1 2Y dy \\ &= Y^2 \Big|_{0.195}^1 \\ &= 1 - 0.038 = 0.962 \quad (96.2\%) \end{aligned}$$

19.20 (a) Use Equations [19.15] and [19.16]. Substitute M for D_M .

$$\begin{aligned} E(M) &= \int_0^1 (M) 3 (1 - M)^2 dm \\ &= 3 \int_0^1 (M - 2M^2 + M^3) dm \\ &= 3 \left[\frac{M^2}{2} - \frac{2M^3}{3} + \frac{M^4}{4} \right]_0^1 \\ &= \frac{3}{2} - 2 + \frac{3}{4} = \frac{6 - 8 + 3}{4} = \frac{1}{4} = 0.25 \end{aligned}$$

$$\begin{aligned} \text{Var}(M) &= \int_0^1 (M^2) 3 (1 - M)^2 dm - [E(M)]^2 \\ &= 3 \int_0^1 (M^2 - 2M^3 + M^4) dm - (1/4)^2 \\ &= 3 \left[\frac{M^3}{3} - \frac{2M^4}{4} + \frac{M^5}{5} \right]_0^1 - 1/16 \\ &= 1 - 3/2 + 3/5 - 1/16 \\ &= (80 - 120 + 48 - 5)/80 \\ &= 3/80 = 0.0375 \end{aligned}$$

$$\sigma = (0.0375)^{0.5} = 0.1936$$

(b) $E(M) \pm 2\sigma$ is $0.25 \pm 2(0.1936) = -0.1372$ and 0.6372

Use the relation defined in Problem 19.19 to take the integral from 0 to 0.6372.

$$\begin{aligned}
P(0 \leq M \leq 0.6372) &= \int_0^{0.6372} 3(1 - M)^2 dm \\
&= 3 \int_0^{0.6372} (1 - 2M + M^2) dm \\
&= 3 \left[M - M^2 + \frac{1}{3} M^3 \right]_0^{0.6372} \\
&= 3 \left[0.6372 - (0.6372)^2 + \frac{1}{3} (0.6372)^3 \right] \\
&= 0.952 \quad (95.2\%)
\end{aligned}$$

19.21 Use Equation [19.8] where $P(N) = (0.5)^N$

$$\begin{aligned}
E(N) &= 1(.5) + 2(.25) + 3(.125) + 4(0.0625) + 5(.03125) + 6(.015625) + 7(.0078125) \\
&\quad + 8(.003906) + 9(.001953) + 10(.0009766) + \dots \\
&= 1.99+
\end{aligned}$$

$E(N)$ can be calculated for as many N values as you wish. The limit to the series $N(0.5)^N$ is 2.0, the correct answer.

19.22 $E(Y) = 3(1/3) + 7(1/4) + 10(1/3) + 12(1/12)$
 $= 1 + 1.75 + 3.333 + 1$
 $= 7.083$

$$\begin{aligned}
\text{Var}(Y) &= \sum Y^2 P(Y) - [E(Y)]^2 \\
&= 3^2(1/3) + 7^2(1/4) + 10^2(1/3) + 12^2(1/12) - (7.083)^2 \\
&= 60.583 - 50.169 \\
&= 10.414
\end{aligned}$$

$$\sigma = 3.227$$

$$E(Y) \pm 1\sigma \text{ is } 7.083 \pm 3.227 = 3.856 \text{ and } 10.310$$

19.23 Using a spreadsheet, the steps in Sec. 19.5 are applied.

1. CFAT given for years 0 through 6.
2. i varies between 6% and 10%.
CFAT for years 7-10 varies between \$1600 and \$2400.
3. Uniform for both i and CFAT values.
4. Set up a spreadsheet. The example below has the following relations:

Col A: = RAND () * 100 to generate random numbers from 0-100.

Col B, cell B13: = INT((.04*A13+6) *100)/10000 converts the RN to i between 0.06 and 0.10. The % designation changes it to an interest rate between 6% and 10%.

Col C: = RAND() * 100

Col D, cell D13: = INT (8*C13+1600) converts RN to a CFAT between \$1600 and \$2400.

Ten samples of i and CFAT for years 7-10 are shown below in columns B and D of the spreadsheet.

	A	B	C	D	E	F	G	H
1						Annual CFAT	Annual CFAT	Annual CFAT
2			RN for	CFAT,		using D4 for CFAT	using D5 for CFAT	using D6 for CFAT
3	RN for i	i	CFAT	years 7-10	Year	and B4 for MARR	and B5 for MARR	and B6 for MARR
4	35.5552	7.42%	13.514	\$ 1,708	0	-28,800	-28,800	-28,800
5	28.6264	7.14%	39.9931	\$ 1,919	1	5,400	5,400	5,400
6	87.6002	9.50%	27.3251	\$ 1,818	2	5,400	5,400	5,400
7	67.6285	8.70%	20.0026	\$ 1,760	3	5,400	5,400	5,400
8	54.9225	8.19%	95.7066	\$ 2,365	4	5,400	5,400	5,400
9	74.1323	8.96%	6.27666	\$ 1,650	5	5,400	5,400	5,400
10	59.7178	8.38%	54.1471	\$ 2,033	6	5,400	5,400	5,400
11	65.7271	8.62%	58.0446	\$ 2,064	7	1,708	1,919	1,818
12	13.8464	6.55%	46.7902	\$ 1,974	8	1,708	1,919	1,818
13	67.1516	8.68%	23.4967	\$ 1,787	9	1,708	1,919	1,818
14					10	4,508	4,719	4,618
15	PW of CFAT, \$					1,708	2,517	-423
16								
17	= INT((0.04*A13+6)*100)/10000			= INT(8*C13+1600)		= NPV(\$B\$6,H5:H14)+H4		
18								

5. Columns F, G and H give 3 CFAT sequences, for example only, using rows 4, 5 and 6 RN generations. The entry for cells F11 through F13 is = D4 and cell F14 is = D4+2800, where S = \$2800. The PW values are obtained using the NPV function.

6. Plot the PW values for as large a sample as desired. Or, following the logic of Figure 19-14, a spreadsheet relation can count the + and – PW values, with mean and standard deviation calculated for the sample.

7. Conclusion:

For certainty, accept the plan since PW = \$2966 exceeds zero at an MARR of 7% per year.

For risk, the result depends on the preponderance of positive PW values from the simulation, and the distribution of PW obtained in step 6.

19.24 Use the spreadsheet Random Number Generator (RNG) on the tools toolbar to generate CFAT values in column D from a normal distribution with $\mu = \$2000$ and $\sigma = \$500$. The RNG screen image is shown below.

Random Number Generation

Number of Variables: 1

Number of Random Numbers: 10

Distribution: Normal

Parameters

Mean = 2000

Standard deviation = 500

Random Seed:

Output options

☒ Output Range: \$D\$4:\$D\$13

☐ New Worksheet Ply:

☐ New Workbook

	A	B	C	D	E	F	G	H
1				RN from		Annual CFAT	Annual CFAT	Annual CFAT
2				Normal		using D4 for CFAT	using D5 for CFAT	using D6 for CFAT
3	RN for i	i		using RNG	Year	and B4 for MARR	and B5 for MARR	and B6 for MARR
4	29.759853	7.19%		2376	0	-28,800	-28,800	-28,800
5	72.035152	8.88%		1643	1	5,400	5,400	5,400
6	41.578308	7.66%		2703	2	5,400	5,400	5,400
7	76.200713	9.04%		2267	3	5,400	5,400	5,400
8	9.5681037	6.38%		1584	4	5,400	5,400	5,400
9	86.148124	9.44%		2187	5	5,400	5,400	5,400
10	32.910316	7.31%		2035	6	5,400	5,400	5,400
11	15.77373	6.63%		2179	7	2,376	1,643	2,703
12	60.962949	8.43%		1812	8	2,376	1,643	2,703
13	72.195817	8.88%		2094	9	2,376	1,643	2,703
14					10	5,176	4,443	5,503
15	PW of CFAT, \$					3,470	-89	3,555
16								

The spreadsheet above is the same as that in Problem 19.23, except that CFAT values in column D for years 7 through 10 are generated using the RNG for the normal distribution described above. The decision to accept the plan uses the same logic as that described in Problem 19.23.

19.25 Answer is (b)

19.26 Answer is (a)

19.27 Answer is (c)

19.28 Answer is (b)

$$\begin{aligned}\mathbf{19.29} \quad P(\$ < 9600) &= P(\$ = 6200) + P(\$ = 8500) \\ &= 0.15 + 0.23 \\ &= 0.38\end{aligned}$$

Answer is (d)

19.30 Answer is (c)

$$\begin{aligned}\mathbf{19.31} \quad s &= \sqrt{1,600,000/(12 - 1)} \\ &= \$381\end{aligned}$$

Answer is (a)

19.32 Two numbers (46 and 27) are in the range 25 to 49, which indicate type B.

$$P(\text{Type B}) = 2/12 = 0.167$$

Answer is (a)

Solution to Case Study, Chapter 19

USING SIMULATION AND 3-ESTIMATE SENSITIVITY ANALYSIS

This simulation is left to the student. The 7-step procedure from Section 19.5 can be applied here. Set up the RNG for the cash flow values of AOC, S, and n for each alternative. For each sample cash flow series, calculate the AW value for each alternative. To obtain a final answer of which alternative is the best, it is recommended that the number of positive and negative AW values be counted as they are generated. Then the alternative with the most positive AW values indicates which one to accept. Of course, due to the RNG generation of AOC, S and n values, this decision may vary from one simulation run to the next.