SEVENTH EDITION

ENGINEERING ECONOMY

SOLUTION MANUAL

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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: e*conomic*; 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 accidently 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*.

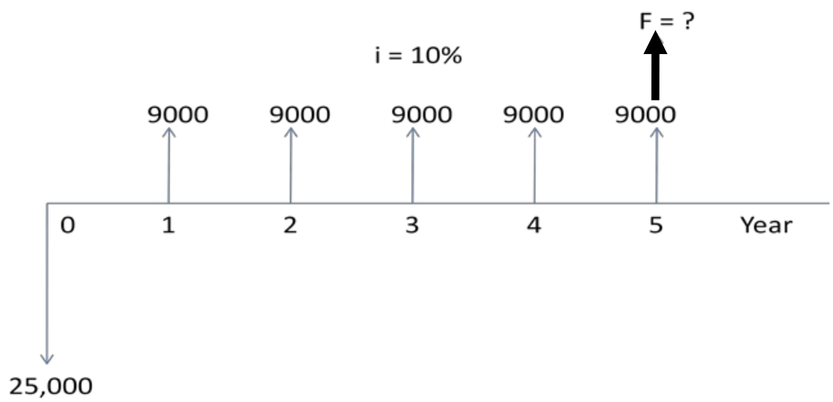
1.21 End-of-period amount for June = 50 + 70 + 120 + 20 = $260
End-of-period amount for Dec = 150 + 90 + 40 + 110 = $390

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	+1100

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

1.23



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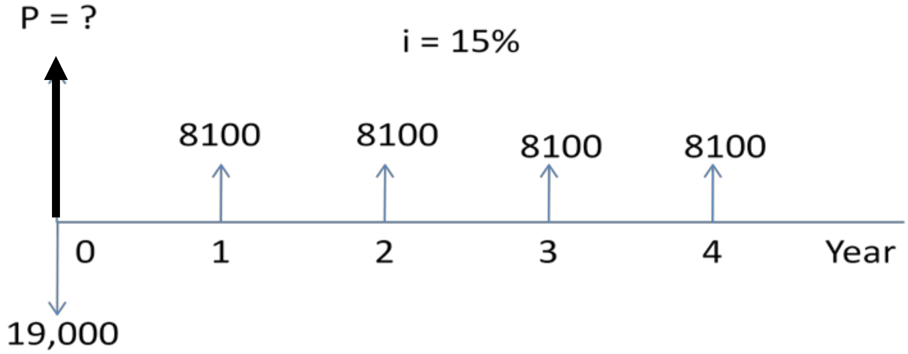

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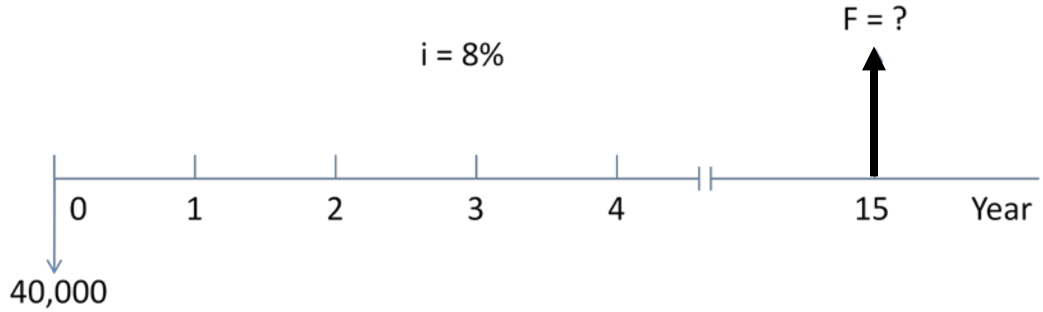

1.26 Amount now = F = 100,000 + 100,000(0.15) = $115,000

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% 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 (10% 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

1.34 $F = 6,000,000(1 + 0.09)(1 + 0.09)(1 + 0.09)$
$= \$7,770,174$

1.35 $4,600,000 = P(1 + 0.10)(1 + 0.10)$
$P = \$3,801,653$

1.36 $86,400 = 50,000(1 + 0.20)^n$
$\log(86,400/50,000) = n(\log 1.20)$
$0.23754 = 0.07918n$
$n = 3$ years

1.37 Simple: $F = 10,000 + 10,000(3)(0.10)$
$= \$13,000$

Compound: $13,000 = 10,000(1 + i)(1 + i)(1 + i)$
$(1 + i)^3 = 1.3000$
$3\log(1 + i) = \log 1.3$
$3\log(1 + i) = 0.1139$
$\log(1 + i) = 0.03798$
$1 + i = 1.091$
$i = 9.1\%$ per year

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 WACC = 0.30(8%) + 0.70(13%) = 11.5%

1.41 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.

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

$X = \$2.526$ 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

2.9 F = 1.3(F/P,18%,10)
= 1.3(5.2338)
= 6.80394 ($6,803,940)

2.10 P = 200,000(P/F,15%,1) + 300,000(P/F,15%3)
= 200,000(0.8696) + 300,000(0.6575)
= $371,170

2.11 Gain in worth of building after repairs = (600,000/0.75 – 600,000) - 25,000 = 175,000

F = 175,000(F/P,8%,5)
= 175,000(1.4693)
= $257,128

2.12 F = 100,000(F/P,8%,4) + 150,000(F/P,8%,3)
= 100,000(1.3605) + 150,000(1.2597)
= $325,005

2.13 P = (110,000* 0.3)(P/A,12%,4)
= (33,000)(3.0373)
= $100,231

2.14 P = 600,000(0.04)(P/A,10%,3)
= 24,000(2.4869)
= $59,686

2.15 A = 950,000(A/P,6%,20)
= 950,000(0.08718)
= $82,821

2.16 A = 434(A/P,8%,5)
= 434(0.25046)
= $108.70

2.17 F = (0.18 – 0.04)(100)(F/A,6%,8)
= 14(9.8975)
= $138.57

2.18 $F_{difference}$ = 10,500(F/P,7%,18) - 10,500(F/P,4%,18)
= 10,500(3.3799) - 10,500(2.2058)
= $12,328

2**.19** F = (200 – 90)(F/A,10%,8)
= 110(11.4359)
= $1,257,949

2.20 A = 350,000(A/F,10%,3)
= 350,000(0.30211)
= $105,739

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

1/2 = x/(0.17102 – 0.14682)
x = 0.0121

(A/P,13%,15) = 0.14682 + 0.0121
= 0.15892

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

2/5 = x/(9.9870 -7.7872)
x = 0.8799

(P/G,27%,10) = 9.9870 – 0.8799
= 9.1071

(b) 1. (A/P,13%,15) = $[0.13(1 + 0.13)^{15}]/[(1 + 0.13)^{15} - 1]$
= 0.15474

2. (P/G,27%,10) = $[(1 + 0.27)^{10} – (0.27)(10) - 1]/[0.27^2(1 + 0.27)^{10}]$
= 9.0676

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

2/5 = x/(4998.22 – 2595.92)
x = 960.92

(F/P,14%,62) = 4998.22 – 960.92
= 4037.30

2. Interpolate between n = 40 and n = 48:
5/8 = x/(0.02046 – 0.01633)
x = 0.00258

(A/F,1%,45) = 0.02046 – 0.00258
= 0.01788

(b) 1. (F/P,14%,62) = $(1+0.14)^{62}$ -1
= 3373.66

2. (A/F,1%,45) = $0.01/[(1+ 0.01)^{45} – 1]$
= 0.01771

(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:

3/5 = x/(72.8905 – 45.2593)
x = 16.5787

(F/P,10%,43) = 45.2593 + 16.5787
= 61.8380

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

% difference = [(61.8380 - 59.2401)/ 59.2401]*100 = 4.4%

2.24 Interpolated value: Interpolate between n = 50 and n = 55:
2/5 = x/(14524 – 7217.72)
x = 2922.51

(F/A,15%,52) = 7217.72 + 2922.51
= 10,140

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

% difference = [(10,140 - 9547.58)/ 9547.58](100)
= 6.2%

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

(b) P = 6000(P/A,8%,5) + 1100(P/G,8%,5)
= 6000(3.9927) + 1100(7.3724)
= $32,066

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

(b) Loss in year 5 = 7 +4(26) = $111 billion

(c) A = 7 + 26(A/G,8%,10)
= 7 + 26(3.8713)
= $107.7 billion

2.27 A = 200 – 5(A/G,8%,8)
= 200 – 5(3.0985)
= $184.51

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

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

(b) $P = 74(P/A,10\%,10) + 4(P/G,10\%,10)$
$= 74(6.1446) + 4(22.8913)$
$= \$546.266$ (\$546,266)

$F = 546.266(F/P,10\%,10)$
$= 521.687(2.5937)$
$= \$1416.850$ (\$1,416,850)

2.30 $601.17 = A + 30(A/G,10\%,9)$
$601.17 = A + 30(3.3724)$
$A = \$500$

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

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

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

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

For n = 1: $P_g = \{1 – [(1 + 0.04)/(1 + 0.10)]^1\}/(0.10 – 0.04)$
$= 0.90909$

$A = 0.90909(A/P,10\%,1)$
$= 0.90909(1.1000)$
$= 1.0000$

For n = 2: $P_g = \{1 – [(1 + 0.04)/(1 + 0.10)]^2\}/(0.10 – 0.04)$
$= 1.7686$

$A = 1.7686(A/P,10\%,2)$
$= 1.7686(0.57619)$
$= 1.0190$

2.34 $P_g = 50,000\{1 – [(1 + 0.06)/(1 + 0.10)]^8\}/(0.10 – 0.06)$
$= \$320,573$

2.35 $P_{g1} = 10,000\{1 – [(1 + 0.04)/(1 + 0.08)]^{10}\}/(0.08 – 0.04)$
$= \$78,590$

$P_{g2} = 10,000\{1 – [(1 + 0.06)/(1 + 0.08)]^{11}\}/(0.08 – 0.06)$
$= \$92,926$

Difference = \$14,336

2.36 $P_g = 260\{1 – [(1 + 0.04)/(1 + 0.06)]^{20}\}/(0.06 – 0.04)$
$= 260(15.8399)$
= \$4118.37 per acre-ft

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

2.38 18,000,000 = 3,576,420(P/A,i,7)
(P/A,i,7) = 5.0330

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).

2.39 813,000 = 170,000(F/P,i,15)
$813,000 = 170,000(1 + i)^{15}$

log 4.78235 = (15)log (1 + i)
0.6796/15 = log (1 + i)
log (1 + i) = 0.04531

1 + i = 1.11
i = 11 % per year

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

2.40 100,000 = 210,325(P/F,i,30)
(P/F,i,30) = 0.47545

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%.

2.41 (1,000,000 – 1,900,000) = 200,000(F/P,i,4)
(F/P,i,4) = 4.5

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.

2.42 800,000 = 250,000(P/A,i,5)
(P/A,i,5) = 3.20

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

2.43 87,360 = 24,000(F/A,i,3)
(F/A,i,3) = 3.6400

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

2.44 48,436 = 42,000 + 4000(A/G,i,5)
6436 = 4000(A/G,i,5)
(A/G,i,5) = 1.6090

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

2.45 600,000 = 80,000(F/A,15%,n)
(F/A,15%,n) = 7.50

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

2.46 Starting amount = 1,600,000(0.55) = $880,000

1,600,000 = 880,000(F/P,9%,n)
(F/P,9%,n) = 1.8182

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

2.47 200,000 = 29,000(P/A,10%,n)
(P/A,10%,n) = 6.8966

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

2.48 1,500,000 = 18,000(F/A,12%,n)
(F/A,12%,n) = 83.3333

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 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 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 years

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

Answer is (d)

2.55 30,000 = 4200(P/A,8%,n)
(P/A,8%,n) = 7.14286

n is between 11 and 12 years

Answer is (c)

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

Answer is (a)

2.57 Answer is (d)

2.58 A = 800 – 100(A/G,4%,6) = $561.43

Answer is (b)

2.59 Answer is (b)

2.60 F = 61,000(F/P,4%,4)
= 61,000(1.1699)
= $71,364

Answer is (c)

2.61 P = 90,000(P/A,10%,10)
= 90,000(6.1446)
= $553,014

Answer is (d)

2.62 A = 100,000(A/P,10%,7)
= 100,000(0.20541)
= $20,541

Answer is (b)

2.63 A = 1,500,000(A/F,10%,20)
= 1,500,000(0.01746)
= $26,190

Answer is (a)

2.64 In $1 million units

A = 3(10)(A/P,10%,10)
= 30(0.16275)
= $4.8825 (≈ $4.9 million)

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)

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

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

C: 2 million = 300,000(P/A,i%,65)

(P/A,i%,64) = 6.666667

i = 15%

D: 30/200 = 15% per week

Simple: 15%(52 weeks) = 780% per year

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

2. A: Start -- $24

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

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

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

End -- 300,000(65) = $19.5 million over 65 years

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

D: Simple interest

Start -- $200

End -- (0.15)(12)(200) + 200 = $1760

Compound interest

Start -- $200

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

3.8 P = (20 – 8) + (20 – 8)(P/A,10%,3) + (30 – 12)(P/A,10%,5)(P/F,10%,3)
+ (30 - 25)(P/F,10%,9)
= 12 + 12(2.4869) + 18(3.7908)(0.7513) + 5(0.4241)
= $95,228

3.9 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 (first payment)

3.10 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 per year

3.11 (a) 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 per year

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

3.12 (a) 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 per year

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

3.13 (a) 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 per year

(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.

3.14 (a) 300 = 200(A/P,10%,7) + 200(P/A,10%,3)(A/P,10%,7) + x(P/F,10%,4)(A/P,10%,7)
+ 200(F/A,10%,3)(A/F,10%,7)
300 = 200(0.20541) + 200(2.4869)(0.20541) + x(0.6830)(0.20541)
+ 200(3.3100)(0.10541)
0.14030x = 300 – 213.03
x = $619.88

(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.

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

Payment in years 2 - 5: A = 8,900,000(A/P,9%,4)
= 8,900,000(0.30867)
= $2,747,163 per year

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 per year

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

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 ($198,197)

A = 198.197(A/P,12%,9)
= 198.197(0.18768)
= $37.197 ($39,197 per year)

3.18 A = -2500(A/P,10%,10) + (700 – 200)(P/A,10%,4)(A/P,10%,10)
+ (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 per year

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 per year

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

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 per year

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 per year

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

3.23 $10A_0 = A_0 + A_0(F/A,7\%,n)$
$9A_0 = A_0(F/A,7\%,n)$
$(F/A,7\%,n) = 9.0000$

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

3.24 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

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

P_2 = 540,000(P/A,10%,8) + 6000(P/G,10%,8)
= 540,000(5.3349) + 6000(16.0287)
= $2,977,018

F = 2,977,018(F/P,10%,8)
= 2,977,018(2.1436)
= $6,381,536

(b) F_{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

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.

-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

3.27 -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

3.28 A = 50,000(A/F,15%,4)
= 50,000(0.20027)
= $10,015

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

F = 74,000(F/A,10%,5) – 42,000(F/P,10%,4)
= 74,000(6.1051) – 42,000(1.4641)
= $390,285

A = 390,285(A/F,10%,4)
= 390,285(0.21547)
= $84,095 per year

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 embeded 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 ($4.578 million)

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

3.35 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 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

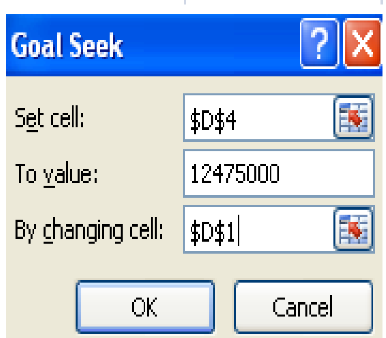
3.38 P = 90(P/A,15%,2) + [90(P/A,15%,8) - 5(P/G,15%,8)](P/F,15%,2)
= 90(1.6257) + [90(4.4873) - 5(12.4807)](0.7561)
= $404.49

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		



3.40 A = 5000(A/P,10%,9) + 5500 + 500(A/G,10%,9)
= 5000(0.17364) + 5500 + 500(3.3724)
= $8054

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)

$P_g = 3.4\{1 – [(1 + 0.03)/(1 + 0.10)]^8\}/(0.10 – 0.03)$
= 3.4{1 – 0.59096}/0.07
= $19.8678

P_0 = 3.4(P/A,10%,2) + 19.8678(P/F,10%,2)
= 3.4(1.7355) + 19.8678(0.8264)
= $22.3194

F_{10} = P_0(F/P,10%,10)
= 22.3194(2.5937)
= $57.8899 ($57,889,900)

(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)).

3.42 $P_{g-1} = 50,000\{1 – [(1 + 0.15)/(1 + 0.10)]^{11}\}/(0.10 – 0.15)$
= 50,000{-0.63063}/-0.05
= $630,630

F = 630,630(F/P,10%,11)
= 630,630(2.8531)
= $1,799,250

3.43 P_0 = 7200(P/A,8%,3) + P_g(P/F,8%,3)

$P_g = 7200\{1 – [(1 + 0.05)/(1 + 0.08)]^6\}/(0.08 – 0.05)$
= 7200{1 – 0.84449}/0.03
= $37,322

P_0 = 7200(P/A,8%,3) + 37,322(P/F,8%,3)
= 7200(2.5771) + 37,322(0.7938)
= $48,181

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,

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

$P_0 = 25.2309 (F/P,15\%,1)$
$= 25.2309 (1.15)$
$= \$29.0156$ ($29,015,600)

3.45 $P_{g-1} = 150,000(6/(1 + 0.10)$
$= \$818,182$

$P_0 = 818,182(F/P,10\%,1)$
$= 818,182(1.1000)$
$= \$900,000$

3.46 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

This is a negative gradient series.

3.47 A = 850(A/P,10%,7) + 800 – 50(A/G,10%,7)
= 850(0.20541) + 800 – 50(2.6216)
= $843.52

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

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

A = 9,312,565(A/P,12%,9)
= 9,312,565(0.18768)
= $1,747,782 per year

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

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

$P_0 = 14,000(2.1743) + 47,525(0.6086)$
$= \$59,364$

$F = P_0(F/P,18\%,10)$
$= 59,364(5.2338)$
$= \$310,700$

(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.

3.50 $P_1 = 470(P/A,10\%,6) – 50(P/G,10\%,6) + 470(P/F,10\%,7)$
$= 470(4.3553) – 50(9.6842) + 470(0.5132)$
$= \$1803.99$

$F = 1803.99(F/P,10\%,7)$
$= 1803.99(1.9487)$
$= \$3515$

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

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

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

$P_0 = 38,000(1.7355) + 110,123(0.8264)$
$= \$156,955$

$A = 156,955(A/P,10\%,7)$
$= 156,955(0.20541)$
$= \$32,240$

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

$P_{g\text{-}1} = 100,000\{1 – [(1 - 0.12)/(1 + 0.12)]^{11}\}/(0.12 + 0.12)$
$= \$387,310$

$F = 387,310(F/P,12\%,11)$
$= 387,310(3.4785)$
$= \$1,347,259$

3.53 Answer is (b)

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

Answer is (c)

3.55 Answer is (a)

3.56 Answer is (b)

3.57 P_{14} = 10,000(P/A,10%,10)
= 10,000(6.1446)
= $61,446

P_3 = 61,446(P/F,10%,11)
= 61,446(0.3505)
= $21,537

Answer is (d)

3.58 Amount in year 6 = 50,000(P/F,8%,6)
= 50,000(0.6302)
= $31,510

A = 31,510(A/F,8%,4)
= 31,510(0.22192)
= $6993 per year

Answer is (a)

3.59 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

Answer is (b)

3.60 A = 1000(A/P,10%,5) + 1000 + 500(A/F,10%,5)
= 1000(0.26380) + 1000 + 500(0.16380)
= $1345.70

Answer is (c)

3.61 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

Answer is (d)

3.62 A = 2,000,000(A/F,10%,5) = 2,000,000(0.16380)
= $327,600

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 +.

	Cash flow	
Year	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) + … + 0.750(P/F,7%,6)

   = $13.1716 ($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 ($5,625,800 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 ($4,748,000 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 = one year; CP = one month; m = 12

4.2 t = one month; CP = 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 or 3.75% 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

4.22 F = 260,000(F/P,3%,12)
= 260,000(1.4258)
= $370,708

4.23 P = 1,700,000(P/F,1.5%,36)
= 1,700,000(0.5851)
= $994,670

4.24 P = 6(190,000)(P/F,7%,4)
= 6(190,000)(0.7629)
= $869,706

4.25 F = 5000(F/P,2%,48) + 7000(F/P,2%,28)
= 5000(2.5871) + 7000(1.7410)
= $25,123

4.26 In $1 million units,

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 ($6,132,400)

4.27 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

4.28 P = 2,000,000(P/A,4%,20)
= 2,000,000(13.5903)
= $27,180,600

4.29 A = 7,000,000(A/P,6%,10)
= 7,000,000(0.13587)
= $951,090

4.30 926 = A(P/A,0.75%,60)
926 = A(48.1734)
A = $19.22

4.31 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 per month

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

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

F = 218,391(F/A,0.5%,10)
= 218,391(10.2280)
= $2,233,708

4.33 $A_{0\%}$ = 3199/12
= $266.58 per month

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

Savings = 275.34 – 266.58
= $8.76 per month

4.34 A = 28(F/A,1.5%,24)(A/P,1.5%,240)
= 28(28.6335)(0.01543)
= $12.3708 million per month

4.35 (a) Interest in payment = 5000(0.02) = $100

(b) 5000 = 110.25(P/A,2%,n)
(P/A,2%,n) = 45.3515

From 2% interest table, n ≈ 120 months or 10 years

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

Interest rate per month = (75/500)(100%) = 15%

F = P(F/P,15%,12)
= 500(5.3503)
= $2675

(b) effective i = $(1 + 0.15)^{12} – 1$
= 4.35 or 435% per year

4.37 300 = 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 per month

4.38 F = 285,000(F/P,2%,60)
= 285,000(3.2810)
= $935,085

4.39 F = 3,600,000(F/P,6%,16)
= 3,600,000(2.5404)
= $9,145,440

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

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

$i = (1 + 0.18/12)^{12} - 1$
= 19.56% per year

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 per year

4.41 $i = (1 + 0.12/12)^{12} - 1$
= 12.68% per year

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.

F = 30(15.2077) + 20(3.3965)
= $524.16

4.42 A = 480 + 20(A/G,0.25%,120)
= 480 + 20(56.5084)
= $1,610,168,000 per month

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

$P_g = 100{,}000\{1 – [(1 + 0.04)/(1 + 0.1038)]^5\}/(0.1038 – 0.04)$
$= 100{,}000(4.03556)$
$= \$403{,}556$

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

F = 3000(F/A,1.5%,20)
= 3000(23.1237)
= $69,371

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

A = 2(950)(A/P,1%,36) + 3300
= 2(950)(0.03321) + 3300
= $3363.10 per month

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

F = 9000(F/A,1.5%,10)
= 9000(10.7027)
= $96,324

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

P = 5400(P/A,7%,6)
= 5400(4.7665)
= $25,739

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

$i = e^{0.144} - 1$
$= 15.49\%$ per year

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

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

$i = e^{0.048} - 1$
$= 4.92\%$ per quarter

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

4.51 $0.25 = e^r - 1$
$e^r = 1.25$
$r = \ln 1.25$
= 0.22.31 or 22.31% per year

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

4.52 $i = e^{0.12} - 1$
= 0.1275 or 12.75% per year

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

Find factor value by interpolation, formula, or spreadsheet.

P = 13,000,000(0.7866)
= $10,226,105

4.53 $i = e^{0.10} - 1$
= 0.10517 or 10.517% per year

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.

P = 150,000 + 200,000(0.9048) + 350,000(0.8187)
= $617,505

4.54 F = 300,000(F/P,1%,4)(F/P,1.25%,8)
= 300,000(1.0406)(1.1045)
= $344,803

4.55 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

Spreadsheet solution: Use embedded FV functions
= FV(10%,2,,FV(8%,3,140000)) + FV(10%,2,-140000)
to display $843,940

4.56 In $1 million units
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

4.57 (a) $P = 100(P/A,10\%,5) + 160(P/A,14\%,3)(P/F,10\%,5)$
$= 100(3.7908) + 160(2.3216)(0.6209)$
$= 100(3.7908) + 160(1.4415)$
$= \$609.72$

(b) $609.72 = A(3.7908) + A(1.4415)$
$A = 609.72/5.2323$
$= \$116.53$ per year

4.58 Answer is (b)

4.59 Answer is (d)

4.60 Answer is (c)

4.61 Answer is (b)

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

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.)

4.63 $i = (1 + 0.02)^6 - 1$
$= 12.62\%$

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

F = 1000(F/A,3%,50)
= $112,796.90

Answer is (d)

4.68 Answer is (d)

4.69 Answer is (b)

4.70 Answer is (a)

4.71 Answer is (c)

4.72 A = 500,000(A/F,7%,12)
= 500,000(0.05590)
= $27,950 per 6 months

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.)	3,000
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.

Loan balance = 297,000(F/P,0.4167%,120) - 2350(F/A,0.4167%,120)

= 297,000(1.6471) - 2350(155.2856)

= $124,268

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} changes to 231,000 - 243,386 = $-12,386 (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} 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 (\$5,359,000)

PW_{Contract} = (3.1 – 2)(P/A,10%,5)
= (3.1 – 2)(3.7908)
= \$4.170 (\$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

PW_B = -51,000 – 17,000(P/A,10%,4)
= -51,000 – 17,000(3.1699)
= $-104,888

Select Machine B

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

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

Select Material X

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

-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

Select Y if first cost is ≤ $32,422

5.10 Find P_g for each stock and select higher one.

$P_{gA} = 30{,}000\{1 – [(1 + 0.06)/(1 + 0.08)]^5\}/(0.08 – 0.06)$
= $133,839

$P_{gB} = 20{,}000\{1 – [(1 + 0.12)/(1 + 0.08)]^5\}/(0.08 – 0.12)$
= $99,710

Select Class A stock

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

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

Select Plan B

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

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

Do not install corrugated pipe

5.13 PW_{250} = -155,000 – 3000(P/A,10%,30)
= -155,000 – 3000(9.4269)
= $-183,281

PW_{300} = $-210,000

Install the 250 mm pipe

5.14 PW_{Gaseous} = -8000 - (650 + 800)(P/A,10%,5)
= -8000 - (1450)(3.7908)
= $-13,497

PW_{Dry} = - (1000 + 1900)(P/A,10%,5)
= - (2900)(3.7908)
= $-10,993

Add dry chlorine

5.15 PW_{Volt} = -35,000 + 15,000(P/F,0.75%,60)
= -35,000 + 15,000(0.6387)
= $-25,420

PW_{Leaf} = -1500 – 349(P/A,0.75%,60)
= -1500 – 349(48.1734)
= $-18,313

Select the Nissan Leaf

5.16 In $ million units,

PW_{Land} = -215 – 22(P/A,15%,50) – 30(P/F,15%,25)
= -215 – 22(6.6605) – 30(0.0304)
= $-362.443 ($-362,443,000)

PW_{Sea} = -350 – 2(P/A,15%,50) – 70(P/F,15%,25)
= -350 – 2(6.6605) – 70(0.0304)
= $-365.449 ($-365,449,000)

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

5.17 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

PW_B = -80,000[1 + (P/F,10%,4)] – 6000(P/A,10%,8)
= -80,000[1 + 0.6830] – 6000(5.3349)
= $-166,649

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

Select Method C

5.18 PW_A = -5,000,000 – 5,500,000(P/A,10%,10)
= -5,000,000 – 5,500,000(6.1446)
= $-38,795,300

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

Select Plan A

5.19 (a) 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

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

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

= NPV(10%,C3:C8) + C2

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,

$$-33.16 = -X_S[1 + (P/F,12\%,5)] - 1.94(P/A,12\%,10) + 0.05X_S[(P/F,12\%,5) + (P/F,12\%,10)]$$
$$= -1.5674X_S - 1.94(5.6502) + 0.0445X_S$$

$$1.5229X_S = -10.9614 + 33.16$$

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

Select seawater option for any first cost ≤ $14.576 million

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

$PW_2 = -83,000 – 1400(P/A,10\%,6) - 2500(P/F,10\%,3)$
$= -83,000 – 1400(4.3553) - 2500(0.7513)$
$= \$-90,976$

Select Plan 1

5.22 Compare PW of costs over 30 years.

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

$PW_{Rubberized} = -(2.20)(110)(43,560)$
$= \$-10,541,520$

Select plastic liner

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

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

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

-6340 = $-M_X$ - 290(P/A,8%,50)
M_x = 6340 - 290(12.2335)
= $2792

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

5.24 (a) PW_{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

PW_{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

$PW_{Contract}$ = –120,000(P/A,10%,6)
= –120,000(4.3553)
= $-522,636

Select private disposal contract

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

$PW_{Contract}$ = -120,000(P/A,10%,2) - 120,000(1.20)(P/A,10%,2)(P/F,10%,2)
- 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

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.

5.26 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

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

Select robot X

5.27 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

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

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

5.28 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

FW_Q = -30,000(F/P,8%,6) – 2500(F/A,8%,6) + 1000
= -30,000(1.5869) – 2500(7.3359) + 1000
= $-64,947

Select alternative Q

5.29 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

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

Select system L

5.30 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

FW_{New} = -1,300,000(F/P,10%,6) – 100,000,000
= -1,300,000(1.7716) – 100,000,000
= $-102,303,080

Difference = 148,503,650 - 102,303,080
= $46,200,570 (higher cost for old contract)

5.31 CC = (-100,000/0.08)(P/F,8%,5)
= -1,250,000(0.6806)
= $-850,750

5.32 (a) CC = -10,000(A/F,3%,5)/0.03
= -10,000(0.18835)/0.03
= $-62,783

(b) CC = -10,000(A/F,8%,5)/0.08
= -10,000(0.17046)/0.08
= $-21,308

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

5.33 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

PE **5.34** Use C to identify the contractor option.

(a) CC_C = -5 million/0.12 = $-41.67 million

Between the three options, select the contractor

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

$P_g = -5{,}000{,}000[1 - (1.02/1.12)^{50}]/(0.12 – 0.02)$
= -5,000,000[9.9069]
= $-49.53 million

A = P_g(A/P,12%,50)
= -49.53 million(0.12042)
= $-5.96 million per year

CC_C = A/i = -5.96 million/0.12
= $-49.70 million

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.

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

CC_M = -88,260/0.10
= $-882,600

CC_N = - 800,000 – 12,000/0.10
= $-920,000

Select alternative M

5.36 CC = -1000/0.10 – 5000(A/F,10%,4)/0.10
= -1000/0.10 – 5000(0.21547)/0.10
= $-20,774

5.37 CC = (-40,000/0.08)(P/F,8%,11)
= (-40,000/0.08)(0.4289)
= $-214,450

5.38 CC = -150,000 – 5000/0.06 – 20,000(P/F,6%,2)
= -150,000 – 5000/0.06 – 20,000(0.8900)
= $-251,133

5.39 Answer is (c)

5.40 Answer is (a)

5.41 Answer is (d)

5.42 Answer is (c)

5.43 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

Answer is (a)

5.44 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

Answer is (c)

5.45 CC = (-40,000/0.10)(P/F,10%,4)
= (-40,000/0.10)(0.6830)
= $-273,200

Answer is (c)

5.46 Answer is (b)

5.47 Answer is (b)

5.48 Answer is (d)

5.49 Answer is (d)

5.50 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

Answer is (b)

5.51 CC = -10,000 - [10,000(A/F,10%,5)]/0.10
= -10,000 - [10,000(0.16380)]/0.10
= $-26,380

Answer is (c)

5.52 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

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	Answers to #1		Answers to #2							
33										

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 per year

6.7 Find PW and convert to AW

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

AW = 97,757(A/P,8%,50)
= 97,757(0.08174)
= $-7,991 per year

6.8 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)
= $-26,741per year

6.9 AW = -2000(P/F,8%,5)(A/P,8%,8) – 800(A/F,8%,2)
= -2000(0.6806)(0.17401) – 800(0.48077)
= $-621 per year

6.10 (a) CR = -285,000(A/P,12%,10) + 50,000(A/F,12%,10)
= -285,000(0.17698) + 50,000(0.05698)
= $-47,590 per year

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

(b) AW = -285,000(A/P,12%,10) + 50,000(A/F,12%,10) + 52,000 - 10,000
-1000(A/G,12%,10)
= -285,000(0.17698) + 50,000(0.05698) + 42,000 - 1000(3.5847)
= $- 9,175 per year

AW was negative

6.11 (a) 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 per year

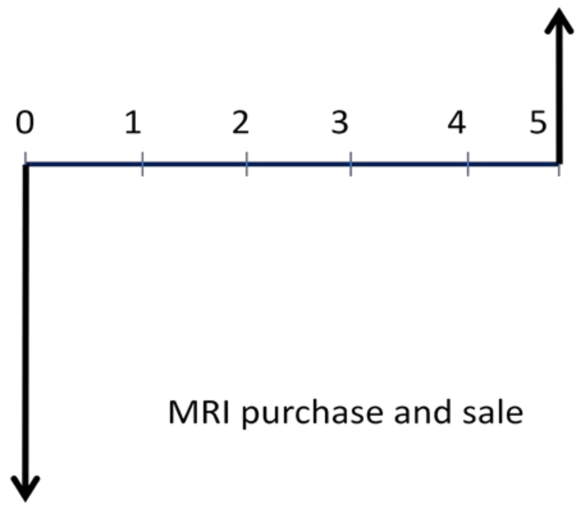
(b) 41,093 = 500,000(A/P,8%,10) - S(A/F,8%,10)
= 500,000(0.14903) - S(0.06903)

S = (74,515 - 41,093)/0.06903)
= $484,166

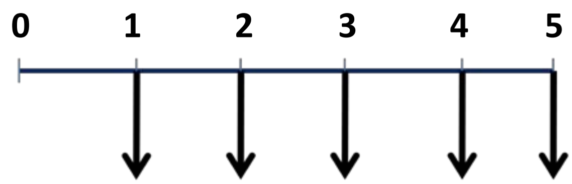
Sales price must be at least 96.8% of purchase price 10 years earlier.

6.12 CR = -750,000(A/P,24%,5) + 75,000(A/F,24%,5)
= -750,000(0.36425) + 75,000(0.12425)
= $-263,869 per year

Cash flow diagrams are shown here.



MRI purchase and sale



CR = $263,869 per year

Capital recovery

6.13 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

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

Use Method X

6.14 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

AW_{Lease} = -2500(A/P,10%,3) - 4200
= -2500(0.40211) – 4200
= $-5,205

The company should lease the car

6.15 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

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

Buy the single-user license

6.16 $AW_{permanent}$ = -3,800,000(A/P,6%,20)
= -3,800,000(0.08718)
= $-331,284

$AW_{portable}$ = -22(7500)
= $-165,000

The city should lease the restrooms

6.17 (a) AW_{Solar} = -16,600(A/P,10%,5) – 2400
= -16,600(0.26380) – 2400
= $-6779 per year

AW_{Line} = -31,000(A/P,10%,5) – 1000
= -31,000(0.26380) – 1000
= $-9178 per year

Use the solar cells

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

-6779 = P_{line}(A/P,10%,5) – 1000
= P_{line}(0.26380) - 1000

P_{line} = $21,906

6.18 AW_{MF} = -33,000(A/P,10%,3) – 8000 + 4000(A/F,10%,3)
= -33,000(0.40211) – 8000 + 4000(0.30211)
= $-20,061

AW_{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

Select the UF system

6.19 (a) AW_{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

AW_{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

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

6.20 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

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

Select Machine R

6.21 $AW_{4\ yrs}$ = -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

$AW_{5\ yrs}$ = -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 per year

Keep the loader for 4 years

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

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

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

(b) AW_{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 per year

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

AW_{Auto1} = -153,718(A/P,10%,5)
= -153,718(0.26380)
= $-40,551per year

Select Auto1 by a relatively small margin

6.23 AW = -200,000(0.10) – 100,000(A/F,10%,7)
= -20,000 - 100,000(0.10541)
= $-30,541 per year

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 per year

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

PW = -[150,000(P/A,10%,4) + 25,000(P/G,10%,4)](P/F,10%,2)
– 225,000(P/A,10%,4)(P/F,10%,6)

= -[150,000(3.1699) + 25,000(4.3781)](0.8264)
– 225,000(3.1699)(0.5645)
= $-886,009

AW = -886,009(A/P,10%,10)
= -886,009(0.16275)
= $-144,198 per year

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

AW_{Torro} = -130,000(0.10) - 2500
= $-15,500 per year

Select the Torro system

6.27 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

6.28 (a) 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

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

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

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				
16				
17				

AW for infinite life Z:
= -650000*(0.1) -13000 - PMT(10%,10,,-80000)

	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.

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

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

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

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

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.

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)
- 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)
- 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)
- 17(4.1002)(0.7130) – 14.2(7.0236)(0.5083) - 2.7(2.6243)(0.3166)
= $-151,710,860

Annual LCC = -151,710,860(A/P,7%,20)
= -151,710,860(0.09439)
= $-14,319,988 per year

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

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)
- 6.3(P/F,6%,5) – 1.36(P/A,6%,15)(P/F,6%,5) - 3.0(P/F,6%,10)
- 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)
- 1.36(9.7122)(0.7473) - 3.0(0.5584) - 3.7(0.3503)
= $-36,000,921

Annual LCC = -36,000,921(A/P,6%,20)
= -36,000,921(0.08718)
= $-3,138,560 per year

6.32 Annual LCC_A = -750,000(A/P,6%,20) - 72,000 - 24,000
– 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
– 150,000[0.7473 + 0.5584 + 0.4173](0.08718)
= $-183,917

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

Select Proposal B

6.33 PW_M = -250,000 – 150,000(P/A,8%,4) – 45,000 – 35,000(P/A,8%,2)
-50,000(P/A,8%,10) – 30,000(P/A,8%,5)
= -250,000 – 150,000(3.3121) – 45,000 – 35,000(1.7833)
-50,000(6.7101) – 30,000(3.9927)
= $-1,309,517

Annual LCC_M = -1,309,517(A/P,8%,10)
= -1,309,517(0.14903)
= $-195,157

PW_N = -10,000 – 45,000 - 30,000(P/A,8%,3) – 80,000(P/A,8%,10)
- 40,000(P/A,8%,10)
= -10,000 – 45,000 - 30,000(2.5771) – 80,000(6.7101) - 40,000(6.7101)
= $-937,525

Annual LCC_N = -937,525(A/P,8%,10)
= -937,525(0.14903)
= $-139,719

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)

6.40 AW_2 = -550,000(A/P,6%,15) +100,000
= -550,000(0.10296) +100,000
= $43,372

Answer is (b)

6.41 Answer is (c)

6.42 Answer is (d)

6.43 Answer is (b)

6.44 Answer is (a)

6.45 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

Answer is (d)

6.46 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

Answer is (c)

6.47 Answer is (c)

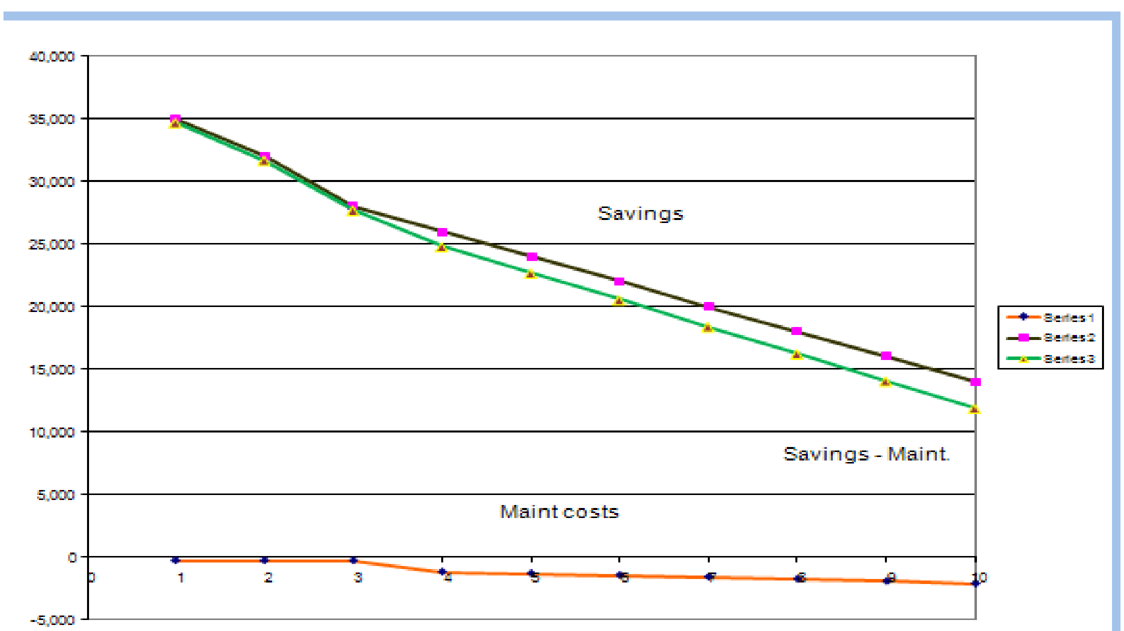
Solution to Case Study, Chapter 6

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:*

Interest on principal = 1,000,000(3)(0.10) = $300,000

Interest charged on unrecovered balance:

Annual payment = 1,000,000(A/P,10%,3)
= 1,000,000(0.40211)
= $402,110

Interest, year 1 = 1,000,000(0.10)
= **$100,000**

Balance, year 1 = 1,100,000 – 402,110
= $697,890

Interest, year 2 = 697,890(0.10)
= **$69,789**

Balance, year 2 = 697,890(1.10) – 402,110
= $365,569

Interest, year 3 = 365,569(0.10)
= **$36,557**

Total interest paid = 100,000 + 69,789 + 36,557
= $206,346

Difference = 300,000 – 206,346
= $93,654

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

7.4 Amount of each payment = 50,000(A/P,10%,5)
= 50,000(0.26380)
= $13,190

Unrecovered balance after 3rd payment = 50,000(F/P,10%,3) – 13,190(F/A,10%,3)
= 50,000(1.3310) – 13,190(3.3100)
= $22,891

7.5 (a) Payment = 50,000,000/10 + 50,000,000(0.10)
= $10,000,000 per year

(b) Total interest paid = [50,000,000(0.10)](10)
= $50,000,000

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

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

0 = -9,000,000 + 7,839,841(P/A,i,3)
(P/A,i,3) = 1.1480

Find i from equation, table, or spreadsheet

i = 69.1% (spreadsheet using RATE function)

7.7 0 = -3.1 + (2)(0.2)(P/A,i,10)
(P/A,i,10) = 7.7500

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

i is between 4% and 5%

i = 4.9% (spreadsheet, equation, or table interpolation)

7.8 0 = -108,000,000 + 59(160,000)(P/A,i%,20)
(P/A,i%,20) = 108,000,000/9,440,000 = 11.4407

i = 6.03% (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

Try 5%: 0 = -3000 - 200(2.7232)(0.9524) - 90(2.7232)(0.7835) + 7000(0.6768)
= $1027.10

Try 10%: $0 = -3000 - 200(2.4869)(0.9091) - 90(2.4869)(0.6209) + 7000(0.4665)$
$= \$-325.60$

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

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% per year (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% (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% *per month* (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% per year (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:

Try 6%: $0 = -225{,}994 + 232{,}460 = \$6466$ i too low
Try 7%: $0 = -220{,}914 + 217{,}070 = -\$3844$ i too high

i = 6.85% per year (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

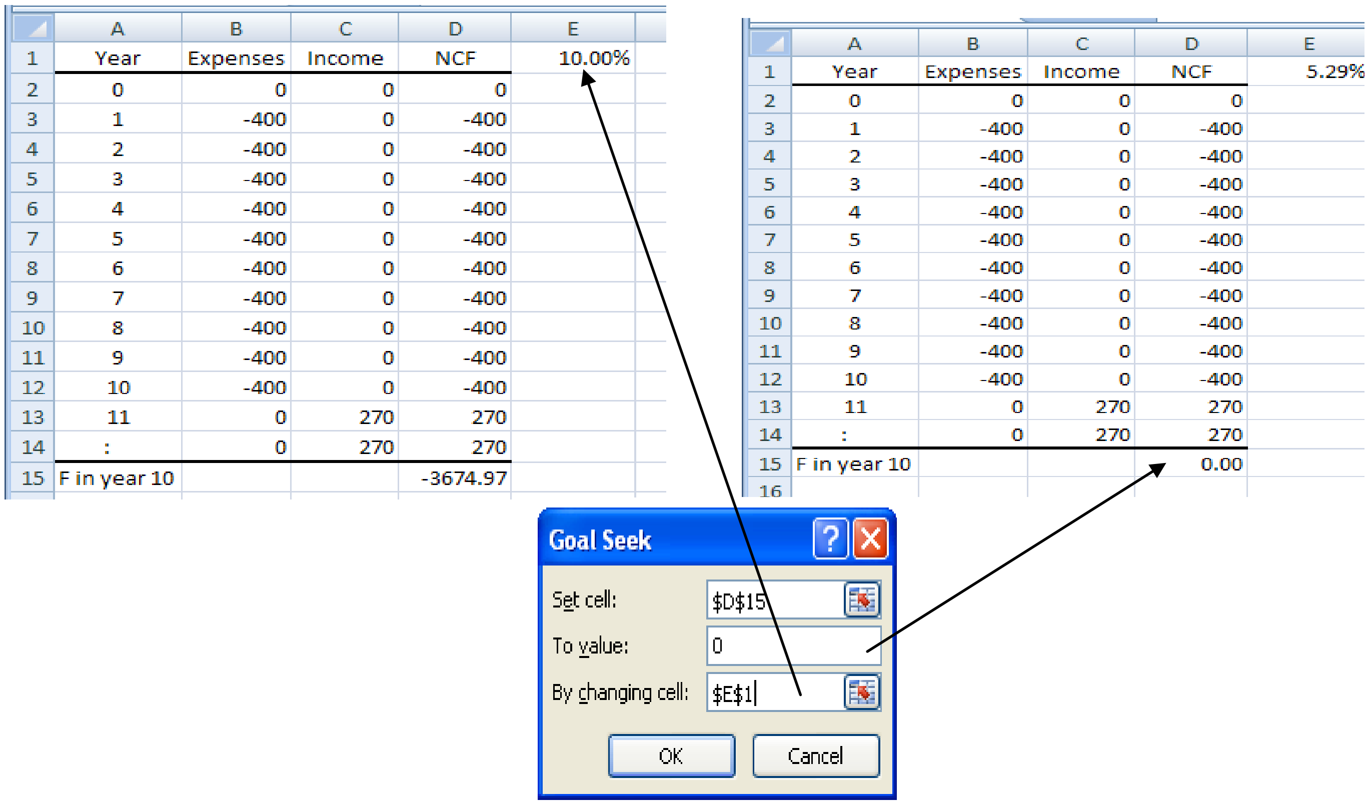
$$0 = -(4{,}000{,}000/10)(F/A,i\%,10) + 270{,}000/i$$

Solve for i by trial and error

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

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					

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.

7.28

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.

7.30

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

Answer is $1000

7.31 (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.

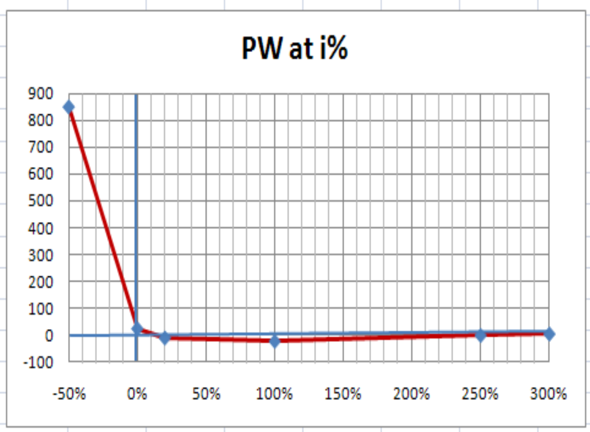
(b) 0 = -30 - 2(P/F,i,1) - 6(P/F,i,2) + 21(P/F,i,3) + 30(P/F,i,4) + 18(P/F,i,5) + 40(P/F,i,6)

Solve for i by trial and error or spreadsheet

i* = 28.3% (IRR function on spreadsheet)

7.32

	A	B	C	D	E
1	Year	CF, $	Cum CF, $	i%	PW at i%
2	0	50	50	-50%	850.00
3	1	-200	-150	0%	25.00
4	2	50	-100	20%	-9.61
5	3	125	25	100%	-21.88
6	Sign changes	2	No help	250%	-0.15
7				300%	5.08
8	Guess	None	100%		
9	ROR	12.2%	251.3%		

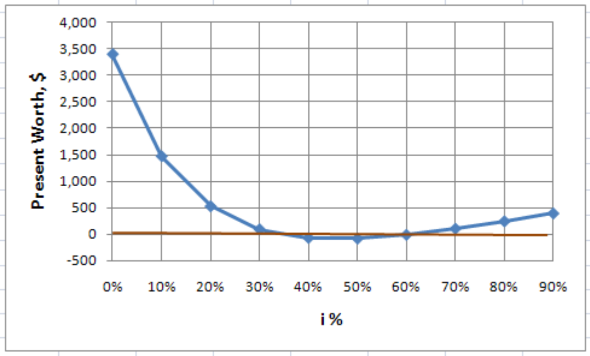


Descartes' rule of signs: 2 sign changes
Norstrom's criterion: series starts positive; no help

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

7.33

	A	B	C	D	E
1	Year	NCF, $	Cum NCF, $	i%	PW at i%, $
2	0	5,000	5,000	0%	3,400
3	1	-10,100	-5,100	10%	1,471
4	2	500	-4,600	20%	526
5	3	2,000	-2,600	30%	90
6	4	2,000	-600	40%	-72
7	5	2,000	1,400	50%	-84
8	6	2,000	3,400	60%	-14
9	Sign changes	2	No help	70%	102
10	Guess	None	100%	80%	241
11	ROR	34.1%	61.4%	90%	391



(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

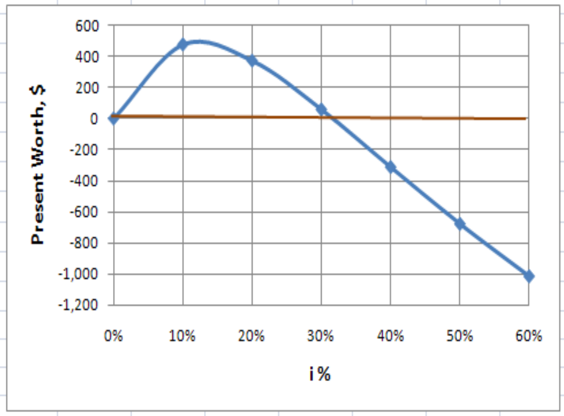
(a) Descartes' rule of signs: 2 sign changes
Norstrom's criterion; series starts negative; 1 sign change
There is one positive root

(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.

Year	NCF, $	Cum NCF, $	i%	PW at i%, $
0	-5,000	-5,000	-10%	-1,985
1	5,000	0	0%	0
2	0	0	10%	477
3	0	0	20%	372
4	15,000	15,000	30%	58
5	-15,000	0	40%	-313
			50%	-679
Sign changes	2	1	60%	-1,017
Guess	None	20%		
ROR	0.0%	31.6%		



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.

PW_0 = – 32,000(P/F,10%,1) – 25,000(P/F,10%,2)
= – 32,000(0.9091) – 25,000(0.8264)
= $-49,751

FW_3 = 16,000(F/P,18%,3) + 70,000
= 16,000(1.6430) + 70,000
= $96,288

96,288 = 49,751(F/P,i,3)
(F/P,i,3) = 1.9354

Use interpolation in factor tables or spreadsheet to find i′

i′ = 24.6% per year (spreadsheet)

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

PW_0 = -9000 - 2000(P/F,8%,2) - 7000(P/F,8%,3)
= -9000 - 2000(0.8573) - 7000(0.7938)
= $-16,271

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

$25{,}722 = 16{,}271(F/P,i,6)$
$(F/P,i,6) = 1.5808$

Use interpolation in factor tables or spreadsheet to find i.

i′ = 7.9% per year (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.

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

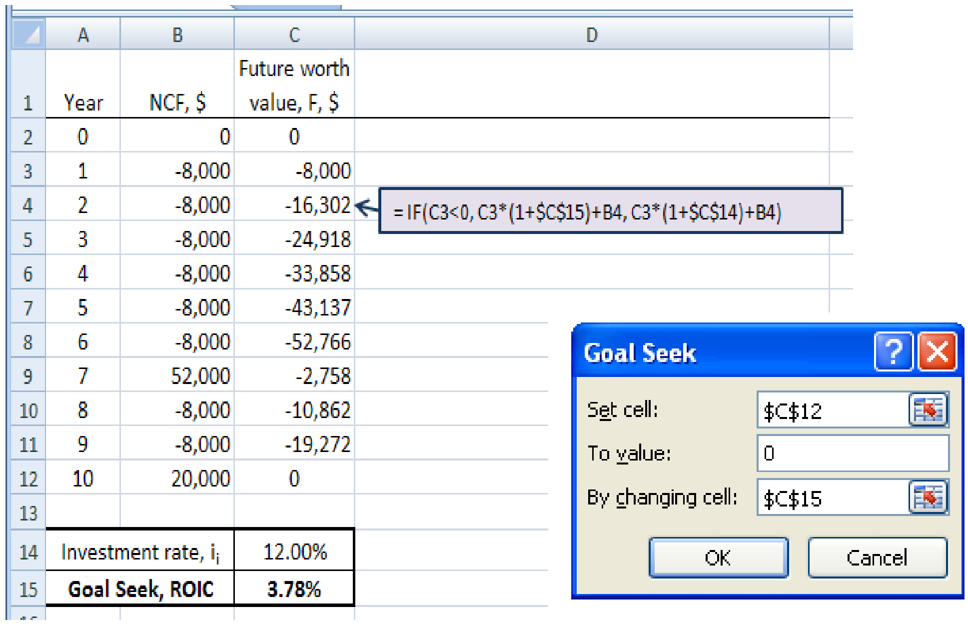
$FW_{10} = 52{,}000(F/P,12\%,3) + 20{,}000$
$= 52{,}000(1.4049) + 20{,}000$
$= \$93{,}055$

$45{,}307(F/P,i,10) = 93{,}055$
$(F/P,i,10) = 2.0539$

Use interpolation in factor tables or spreadsheet to find i′

i′ = 7.5 % per year (spreadsheet)

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



	A	B	C	D
1	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%**	

(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.

PW_0 = -400,000 – 30,000(P/F,9%,3)
= -400,000 – 30,000(0.7722)
= $-423,166

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

0 = -423,166 + 3,580,074(P/F,i,10)
(P/F,i,10) = 0.1182

Solve by formula or spreadsheet

i′ = 23.8% per year (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.

$F_1 = -65 – 65i'' + 30$

$F_2 = (-65 – 65i'' + 30)(1 + i'') + 84$
$= -65 - 65i'' + 30 – 65i'' – 65i''^2 + 30i'' +84$
$= -65i''^2 –100i'' + 49$

$F_3 = (-65i''^2 –100i''+ 49)(1.15) – 10$
$= -74.8 i''^2 –115i'' + 56.4 – 10$
$= -74.8 i''^2 –115i'' + 46.4$

$F_4 = (-74.8 i''^2 –115i'' + 46.4)(1.15) –12$
$= -86 i''^2 –132.3i'' + 53.3 – 12$
$= -86 i''^2 –132.3i'' + 41.3$

Solve by quadratic equation, trial and error, or spreadsheet.

i″ = 26.6% per year (spreadsheet)

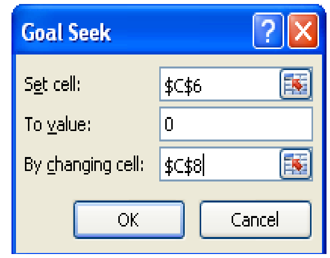
Spreadsheet solution: Using the format and functions of Figure 7-12, i″ = 26.62%.

	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: $F_0 = 3000$ $\quad$ $F_0 > 0$; use i_i

$F_1 = 3000(1 + 0.14) - 2000$
$= 1420$ $\quad$ $F_1 > 0$; use i_i

$F_2 = 1420(1 + 0.14) + 1000$
$= 2618.80$ $\quad$ $F_2 > 0$; use i_i

$F_3 = 2618.80(1 + 0.14) – 6000$
$= -3014.57$ $\quad$ $F_3 < 0$; 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,

$F_0 = -5000$ $\quad$ $F_0 < 0$; use i″

$F_1 = -5000(1 + i'') + 4000$
$= -5000 – 5000\, i'' + 4000$
$= -1000 – 5000\, i''$ $\quad$ $F_1 < 0$; use i″

$F_2 = (-1000 - 5000\, i'')(1 + i'')$
$= -1000 - 5000\, i'' - 1000\, i'' - 5000\, i''^2$
$= -1000 - 6000\, i'' - 5000\, i''^2$ $F_2 < 0$; use i''

$F_3 = (-1000 - 6000\, i'' - 5000\, i''^2)(1 + i'')$
$= -1000 - 6000\, i'' - 5000\, i''^2 - 1000\, i'' - 6000\, i''^2 - 5000\, i''^3$
$= -1000 - 7000\, i'' - 11{,}000\, i''^2 - 5000 i^3$ $F_3 < 0$; use i''

$F_4 = (-1000 - 7000\, i'' - 11{,}000\, i''^2 - 5000 i^3)(1 + i'') + 20{,}000$
$= 19{,}000 - 8000\, i'' - 18{,}000\, i''^2 - 16{,}000 i^3 - 5000\, i''^4$ $F_4 > 0$; use i_i

$F_5 = (19{,}000 - 8000\, i'' - 18{,}000\, i''^2 - 16{,}000\, i''^3 - 5000\, i''^4)(1.15) - 15{,}000$
$= 6850 - 9200\, i'' - 20{,}700\, i''^2 - 18{,}400\, i''^3 - 5750\, i''^4$

Set $F_5 = 0$ and solve for i'' by trial and error or spreadsheet for the ROIC approach.

$i'' = 35.7\%$ 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% per year, payable semiannually

7.46 I = 10,000(0.08)/4
= $200 every three months

7.47 900 = (V)(0.06)/2
V = $30,000

7.48 I = 50,000(0.08)/4
= $1000 per quarter

Find P of all future payments for 15 years

P = 1000(P/A,1.5%,60) + 50,000(P/F,1.5%,60)
= 1000(39.3803) + 50,000(0.4093)
= $59,845

7.49 I = 20,000(0.08)/2
= $800 per six months

Find P of all future payments for 16 years

P = 800(P/A,6%,32) + 20,000(P/F,6%,32)
= 800(14.0840) + 20,000(0.1550)
= $14,367

7.50 I = 9,125,000(0.04)/4 = $91,250 per quarter

P = 91,250(P/A,1.5%,72)
= 91,250(43.8447)
= $4,000,829

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% 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% 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
1	Year	NCF, $	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, $
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 ±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 $30{,}000(0.15) + (100{,}000 - 30{,}000)(ROR_{Z2}) = 100{,}000(0.30)$

$ROR_{Z2} = .364$ (36.4%)

8.9 Overall ROR = [100,000(0.24) + 300,000(0.18) + 200,000(0.30)]/600,000
= 0.23 (23%)

8.10 (a) year 0: Incremental 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 CF_2 = 13,000 + 12,000
= $25,000

8.11

Year	X	Y	Y - X
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	-31,600	-19,400+8,000	+20,200
	-196,400	-159,600	+36,800

8.12

Year	Alternative Q	Alternative P	Q - P
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	34,600
			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.

First cost of A: $5000 + (0 - P_A) = 12,000$
$P_A = \$-7000$

(b) First cost of B: $-20,000 = P_B - (-7000)$
$P_B = \$-27,000$

8.14 (a) $-40,000 = P_{Diesel} - (-150,000)$
$P_{Diesel} = \$-190,000$

(b) $11,000 = M\&O_{Diesel} - (-41,000)$
$M\&O_{Diesel} = \$-30,000$

(c) $16,000 = S_{Diesel} - (+23,000)$
$S_{Diesel} = \$39,000$

8.15 (a) $-14,000 = -65,000 - P_{Anodize}$
$P_{Anodize} = \$-51,000$

(b) $5000 = P_{PC} - (-21,000)$
$P_{PC} = \$-16,000$

(c) $2000 = 6000 - S_{Anodize}$
$S_{Anodize} = \$4000$

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% < 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%: PW = -45,000 + 15,000(2.1680) + 45,000(0.3644) + 6000(0.1328)
= $4715 (i too low)

Try i = 50%: 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 Δi^* > 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

Δi* = 6.8% per year (RATE function on spreadsheet)

Δi* > 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

Δi* = 7.5% < MARR of 20%; select additive A (spreadsheet)

8.21 (a) Construct tabulation to get incremental cash flow.

Year	Cash flows, $1000 Type Fe	Cash flows, $1000 Type Al	Incremental 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

$0 = -130 + 18(P/A,\Delta i^*,4) + 120(P/F,\Delta i^*,2) + 40(P/F,\Delta i^*,4)$

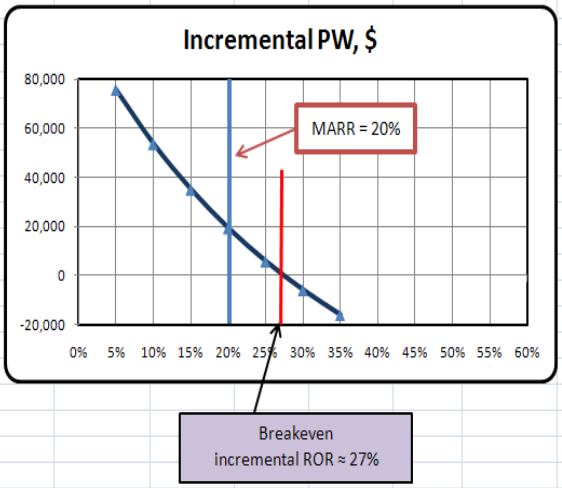
Spreadsheet: Enter incremental cash flows and use IRR function to display

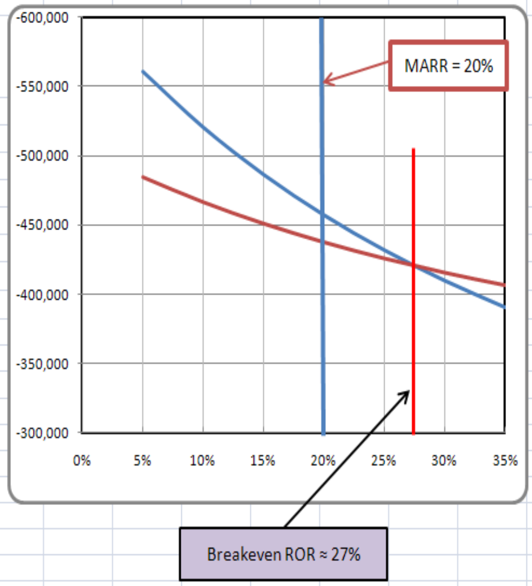
Δi* = 27.3%

Since 27.3% > MARR = 20%; select type Al (spreadsheet)

(b) and (c) Plots are developed using i and Δi values. Decision is the same to select Al.

	Type Fe		Type Fe	Type Al			
Year	Cash flow, $	i and Δi, %	PW, $	Cash flow, $	PW, $	Incremental cash flow, $	Incremental PW, $
0	-150,000	5%	-560,390	-280,000	-484,811	-130,000	75,579
1	-92,000	10%	-520,311	-74,000	-466,759	18,000	53,552
2	-212,000	15%	-486,243	-74,000	-451,246	138,000	34,997
3	-92,000	20%	-457,029	-74,000	-437,809	18,000	19,221
4	-62,000	25%	-431,779	-4,000	-426,086	58,000	5,693
		30%	-409,796		-415,793		-5,997
		35%	-390,531		-406,699		-16,169
Δi* value						27.35%	





8.22 $0 = -900{,}000 + AOC(P/A,40\%,3)$

$0 = -900{,}000 + AOC(1.5889)$

AOC = $566,430

Required reduction = 566,430 – 400,000

= $166,430 per year

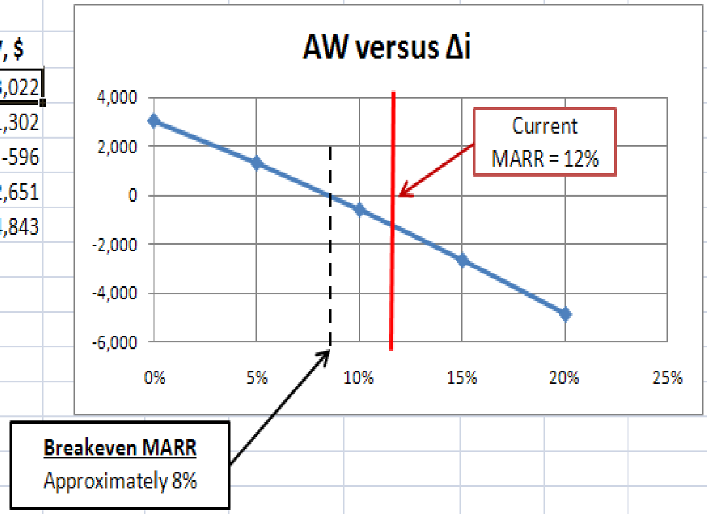
8.23 (a) $0 = -56{,}000(A/P,\Delta i^*,9) + 8900 + (12{,}000 - 8900)(A/F,\Delta i^*,9)$

Solve for Δi* by trial and error or spreadsheet

$\Delta i^* = 8.5\% <$ MARR; select Dryloc (spreadsheet)

(b) The maximum MARR is Δi* = 8.5%. Any MARR > 8.5% indicates selection of Dryloc.

	A	B	C	D
1		Dryloc - NPT		
2	Year	ΔCash flow, $	Δi, %	AW, $
3	0	-56,000	0%	3,022
4	1	8,900	5%	1,302
5	2	8,900	10%	-596
6	3	8,900	15%	-2,651
7	4	8,900	20%	-4,843
8	5	8,900		
9	6	8,900		
10	7	8,900		
11	8	8,900		
12	9	12,000		
13				
14	Δi* value	8.5%		
15				



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

Δi* = 21.8% (RATE function))

Δi* > 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

Δi* = 8.0% (spreadsheet)

Δi* < MARR = 18%; select DBB valves

8.26 (a) EMT has a larger initial investment than HP

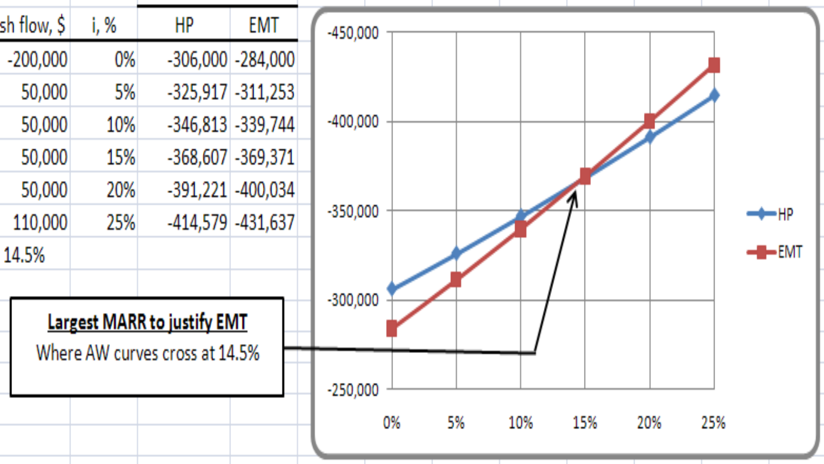
$$0 = -200{,}000(A/P, \Delta i^*,5) + 50{,}000 + 60{,}000(A/F, \Delta i^*,5)$$

Solve for Δi* by trial and error or spreadsheet

Δi* = 14.5% (RATE function)
Δi* < MARR; select hydraulic machine (HP)

(b) Graph of AW of costs versus i values

	A	B	C	D	E	F	G
1		HP	EMT	Incremental		AW of costs	
2	Year	Cash flow, $	Cash flow, $	Cash flow, $	i, %	HP	EMT
3	0	-600,000	-800,000	-200,000	0%	-306,000	-284,000
4	1	-200,000	-150,000	50,000	5%	-325,917	-311,253
5	2	-200,000	-150,000	50,000	10%	-346,813	-339,744
6	3	-200,000	-150,000	50,000	15%	-368,607	-369,371
7	4	-200,000	-150,000	50,000	20%	-391,221	-400,034
8	5	-130,000	-20,000	110,000	25%	-414,579	-431,637
9	Δi*			14.5%			



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%: Δi* = 25.1% < MARR; select A

MARR = 20%: Δi* = 25.1% > MARR; 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% (eliminate)
i_{55}* = 6.0% (eliminate)
i_{88}* = 10.7% (retain)

Rank remaining alternative by increasing initial investment: DN, 88

DN vs 88: $0 = -61{,}000 + 7500(P/A, \Delta i^*,20)$
$(P/A, \Delta i^*,20) = 8.1333$

Solve for Δi* by trial and error or spreadsheet

Δi* = 10.7% per year (RATE function)

Δi* > MARR = 10%; 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.

$i_{\text{iGen-1}}$* = -12.6% (eliminate)
$i_{\text{iGen-2}}$* = -2.7% (eliminate)
$i_{\text{iGen-3}}$* = 4.3% (eliminate)
$i_{\text{iGen-4}}$* = 17.8% (retain)

iGen-4 vs DN: $0 = -750{,}000 + 310{,}000(P/A,\Delta i^*,3) + 120{,}000(P/F,\Delta i^*,3)$

Δi* =17.8%; select iGen-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 vs 2: $0 = -2000 + 3300(P/A, \Delta i^*,4)$
Δi* = 161%; eliminate 2

3 vs 1: $0 = -3500 - 1000(P/A, \Delta i^*,4)$
Δi* < 0%; eliminate 3

5 vs 1: $0 = -10{,}000 + 500(P/A, \Delta i^*,4)$
Δi* < 0%; eliminate 5

4 vs 1: $0 = -18{,}000 + 3800(P/A, \Delta i^*,4)$
Δi* = -6.4%; 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 ≥ 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: Δi* = 14%; eliminate B; select alternative C

(b) Rank alternatives: E,D,C,B,A; eliminate E because overall ROR < MARR

C vs. D: Δi* = 35%, eliminate D
B vs. C: Δi* = 14%, eliminate C
A vs. B: Δi* = 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 Δi* = ΔA/ΔP

A vs. B: Δi* = (700/10,000) = 7% per year

Δi* < 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

Year	A	B	B - A
0	-10,000	-14,000	-4000
1	+2500	+4000	+1500
2	+2500	+4000	+1500
3	+2500	+4000	+1500
4	+2500	+4000	+1500
5	+2500	+4000	+1500
			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* < MARR = 12%. Perform an incremental analysis of #1 (n = 4) and #2 (n = 5). Column H shows Δi* = 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	35,000	70,000	35,000	70,000	70,000	0
11	7				70,000	35,000	70,000	35,000	70,000	70,000	0
12	8				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
42	38								70,000	70,000	0
43	39								70,000	70,000	0
44	40								70,000	70,000	0
45										Δi*	#DIV/0!
46										PW at 3000%	0.01

LCM = 20 years

LCM = 40 years

Some rows hidden

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.

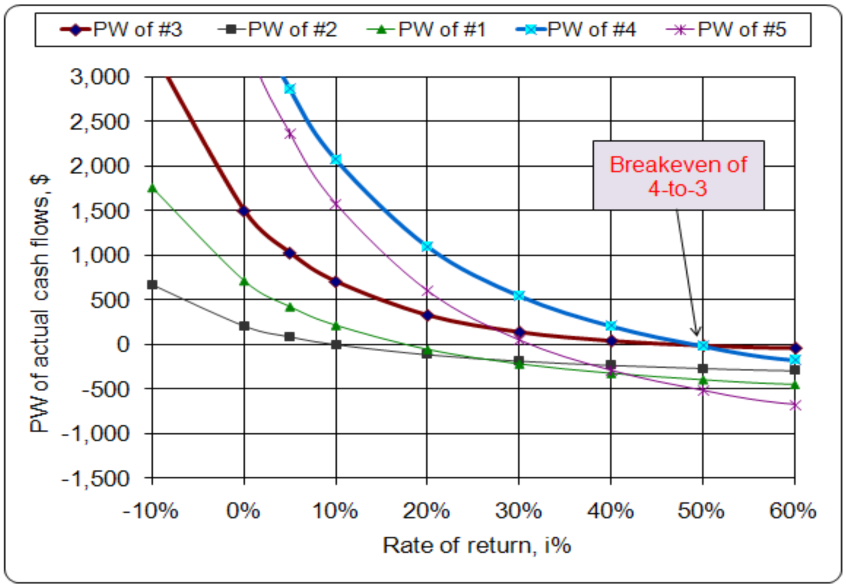
	A	B	C	D	E	F	G	H	I
1	MARR =	25%	**ROR, PW, AW analysis**		(Cash flows, $1000 units)				
2	Alternative		**#3**	**#2**	**#1**	**#4**		**#5**	
3	Initial cost		0	-400	-750	-1,000		-1,500	
4	Est. annual expenses		$-1250,yrs 1-5	$-1400(1-5);-2000(6-10)	$-800+6%/yr	-3,000		-500	
5	Est. annual revenues		$1150 (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.

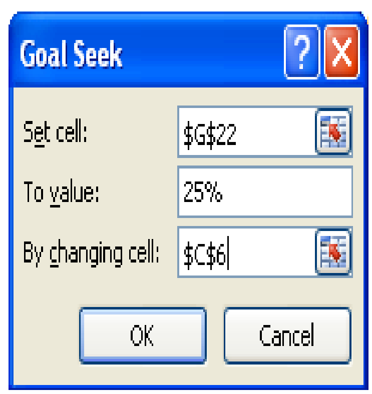
   Conclusion: Select option #4 – trade-out with friend.

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
(b) Benefit
(c) Benefit
(d) Cost
(e) Benefit
(f) Disbenefit
(g) Disbenefit
(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 to (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

C = 300,000 + 25,000(P/A,6%,20)
= 300,000 + 25,000(11.4699)
= $586,748

B/C = 450,000/586,748 = 0.77

9.9 B/C = [50(4,000,000)]/[200(90,000,000)]
= 0.01

9.10 B = 90,000
D = 10,000

C = 750,000(A/P,8%,20) + 50,000
= 750,000(0.10185) + 50,000
= $126,388

S = 30,000

B/C = (B-D)/(C-S)
= (90,000 – 10,000)/(126,388 – 30,000)
= 0.83

9.11 B = $820,000
D = $400,000

C = 2,000,000(A/P,8%,20) + 100,000
= 2,000,000(0.10185) + 100,000
= $303,700

B/C = (820,000 – 400,000)/303,700
= 1.38

9.12 First convert all cash flows to AW values

B = 30,800,000(A/F,7%,20)
= 30,800,000(0.02439)
= $751,212

D = $105,000

C = 1,200,000(A/P,7%,20) + 400,000
= 1,200,000(0.09439) + 400,000
= $513,268

B/C = (751,212 – 105,000)/513,268
= 1.26

9.13 B/C = [10,000/0.10]/[50,000 + 50,000(P/F,10%,2)]
= [100,000]/[50,000 + 50,000(0.8264)]
= 1.1

9.14 (a) PI does not include disbenefits. NCF are savings plus benefits.

PW of NCF = 20,000 + 30,000(P/F,10%,5) + 2000(P/A,10%,20)
= 20,000 + 30,000(0.6209) + 2000(8.5136)
= $55,654

C = $50,000

PI = 55,654/50,000
= 1.11

(b) Modified B/C includes disbenefit estimates and savings are added to benefits.

B = 20,000 + 30,000(P/F,10%,5)
= 20,000 + 30,000(0.6209)
= $38,627

D = 3000(P/A,10%,10)
= 3000(6.1446)
= $18,433

C = $50,000

S = 2000(P/A,10%,20)
= 2000(8.5136)
= $17,027

Modified B/C = (38,627 - 18,433 + 17,027)/50,000
= 37,221/50,000
= 0.74

9.15 Must find n so that one of missing values can be calculated. Use first cost.

100,000 = 259,370(P/F,10%,n)
(P/F,10%,n) = 0.3855

From 10% interest table and P/F column, n = 10

PW benefits = 40,000(P/A,10%,10)
= 40,000(6.1446)
= $245,784

(B – D)/C = (245,784 – 30,723)/(100,000 + 61,446)
= 1.33

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.

Modified B/C = (AW of B - AW of C)/(AW of P) = 1.0

AW of P = (AW of B) - (AW 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

Annual upkeep cost = 120,000

Initial investment = P(i) = 2,300,000(0.06) = $138,000 per year

Modified B/C = (340,000 – 40,000 – 120,000)/138,000
= 1.30

9.20 Use annual worth, since most of the cash flows are in annual dollars.

(a) Conventional B/C ratio

B = 300,000(0.06) + 100,000
= 18,000 + 100,000
= $118,000

D = $40,000

C = 1,500,000(0.06) + 200,000(P/F,6%,3)(0.06)
= 90,000 + 200,000(0.8396)(0.06)
= $100,075

S = 70,000

B/C = (118,000 – 40,000)/(100,075 – 70,000)
= 2.59

(b) Modified B/C ratio = (B – D + S)/C
= (118,000 – 40,000 + 70,000)/100,075
= 1.48

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.

B = (A/0.08)(A/F,8%,5)
D = [40,000(100,000) + 1B]/5 = $1B per year for 5 years
C = 11B/5 = $2.2B per year for 5 years

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

2.2B = 0.17046A/0.08 - 1B
A = $1.5018 billion per year

9.22 B = 30(4,000,000) = $120 million per year

C = 20,000(100,000)(A/P,10%,15)
= 2 billion(0.13147)
= $262.940 million per year

B/C = 120 million/262.940 million
= 0.46

9.23 B = 8,200,000 + 13,000(460) = $14,180,000 per year

C = 220,000,000(A/P,6%,30)
= 220,000,000(0.07265)
= $15,983,000

B/C = 14,180,000/15,983,000
= 0.89

9.24 B = 20,000 + 30,000(P/F,6%,5)
= 20,000 + 30,000(0.7473)
= $42,419

D = 7000(P/F,6%,3)
= 7000(0.8396)
= $5877

C = $100,000

S = 25,000(P/A,6%,4)
= 25,000(3.4651)
= $86,628

(B – D)/(C – S) = (42,419 – 5877)/(100,000 – 86,628)
= 2.73

9.25 The modified B/C ratio includes any estimated disbenefits; the PI does not

9.26 In $ million units,

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

PW of investments = 4.2 + 3.5(P/F,8%,5)
= 4.2 + 3.5(0.6806)
= $6.58

PI = 11.58/6.58 = 1.76

9.27 In $1000 units,

PW of NCF = 5(P/A,10%,6) + 2(P/G,10%,6)
= 5(4.3553) + 2(9.6842)
= $41.14

PW of investments = 25 + 10(P/F,10%,2) + 5(P/F,10%,4)
= 25 + 10(0.8264) + 5(0.6830)
= $36.68

PI = 41.14/36.68
= 1.12

The project was economically justified since 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

C = 4,200,000(A/P,8%,20) + 280,000
= 4,200,000(0.10185) + 280,000
= $707,770

B/C = 450,000/707,770
= 0.64

Eliminate mountain site

VS vs. DN: B = (890,000,000)(3.00/1000)
= $2,670,000

C = 11,000,000(A/P,8%,20) + 400,000
= 11,000,000(0.10185) + 400,000
= $1,520,350

B/C = 2,670,000/1,520,350
= 1.76

Select VS, the valley site, since B/C > 1.0

9.31 East vs. DN: $(B\text{-}D)_{East}$ = 990,000 – 120,000 = \$870,000 per year

C_{East} = 11,000,000(0.06) + 100,000 = \$760,000 per year

(B-D)/C = 870,000/760,000
= 1.14

Eliminate DN

West vs. East: Δ(B-D) = (2,400,000 – 100,000) – (990,000 – 120,000) = \$1,430,000

ΔC = [27,000,000(0.06) + 90,000] – 760,000 = \$950,000

ΔB/C = 1,430,000/950,000
= 1.51

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

B/C = (530,000 – 300,000)/254,127
= 0.91

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

B/C = (650,000 – 195,000)/233,145
= 1.95

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.

ΔB = 700,000 – 5000 = 695,000

$\Delta C = (2{,}500{,}000 – 300{,}000)(A/P,8\%,5)$
$= (2{,}200{,}000)(0.25046)$
$= 551{,}012$

$\Delta B/C = 695{,}000/551{,}012$
$= 1.26$ Eliminate conventional

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

(B-D)/C = (110,000 – 26,000)/54,410
= 1.54   Eliminate DN

NS vs EC: ΔB = 160,000 – 110,000
= $50,000

ΔD = 0 – 26,000
= $-26,000

Cost EC = $54,410 (from above)

Cost NS = 87,000(A/P,7%,10) + 64,000
= 87,000(0.14238) + 64,000
= $76,387

ΔC = 76,387 - 54,410
= $21,977

Δ(B-D)/C = [50,000 - (-26,000)]/21,977
= 3.46   Eliminate EC

Select NS, the new sensors

9.35 Both are cost alternatives; no comparison to DN.

Cost for method #1 = 14,100 + 6000 + 4300 + 2600
= $27,000

Cost for method #2 = $5200 + 1400 + 2600 + 1200
= $10,400

#2 vs. #1: $\Delta C = 27{,}000 - 10{,}400$
$= \$16{,}600$

$\Delta B = 600(P/A,7\%,20)$
$= 600(10.5940)$
$= \$6356$

$\Delta B/C = 6356/16{,}600$
$= 0.38$ Eliminate #1

Select method #2

9.36 Alternatives involve only costs; DN is not an option. Calculate AW of total costs.

$C_{SS} = 26{,}000{,}000(A/P,8\%,20) + 400{,}000$
$= 26{,}000{,}000(0.10185) + 400{,}000$
$= \$3{,}048{,}000$

$C_{OC} = 53{,}000{,}000(A/P,8\%,20) + 30{,}000$
$= 53{,}000{,}000(0.10185) + 30{,}000$
$= \$5{,}428{,}000$

Cleanup costs are a benefit to OC

$\Delta B = \$60{,}000$

$\Delta B/C = (60{,}000 - 0)/ (5{,}428{,}000 - 3{,}048{,}000)$
$= 0.03$ 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.

ΔB = difference in road user costs between long and short route
$= 400{,}000(25)(0.30) - 400{,}000(10)(0.30)$
$= \$1{,}800{,}000$

$\Delta C = (45M - 25M)(0.08) + (35{,}000 - 150{,}000)$
$= \$1{,}485{,}000$

$\Delta B/C = 1{,}800{,}000/1{,}485{,}000$
$= 1.21$

Select short transmountain route, since $\Delta B/C > 1.0$

(b) Modified ΔB/C = (ΔB - Δannual costs)/Δinitial investment

ΔB = [400,000(25)(0.30) – 400,000(10)(0.30)] - (35,000 – 150,000)
= 1,915,000

Δinitial investment = (45,000,000 – 25,000,000)(0.08)
= $1,600,000

Modified ΔB/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

AW of C = 3,000,000(0.12) + 50,000
= $410,000

Revenue = B = $500,000 per year
Disbenefits = D = $30,000 per year

Location W

AW of C = 7,000,000 (0.12) + 65,000 - 25,000
= $880,000

Revenue = B = $700,000 per year
Disbenefits = D = $40,000 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.

W vs. E: ΔC = 880,000 – 410,000
= $470,000

ΔB = 700,000 – 500,000
= $200,000

ΔD = 40,000 – 30,000
= $10,000

Δ(B-D)/C = (200,000 – 10,000)/470,000
= 0.40

Since Δ(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

Modified B/C = 420,000/360,000 = 1.17

Location E is justified. Incrementally compare W to E.

W vs. E: ΔB = $200,000
ΔD = $10,000

Δinitial cost = (7 million – 3 million)(0.12)
= $480,000

Δoperating costs = (65,000 – 25,000) – 50,000
= $-10,000

Note that operating cost is now an incremental advantage for W.

$$\text{Modified } \Delta B/C = \frac{200{,}000 - 10{,}000 - (-10{,}000)}{480{,}000} = 0.42$$

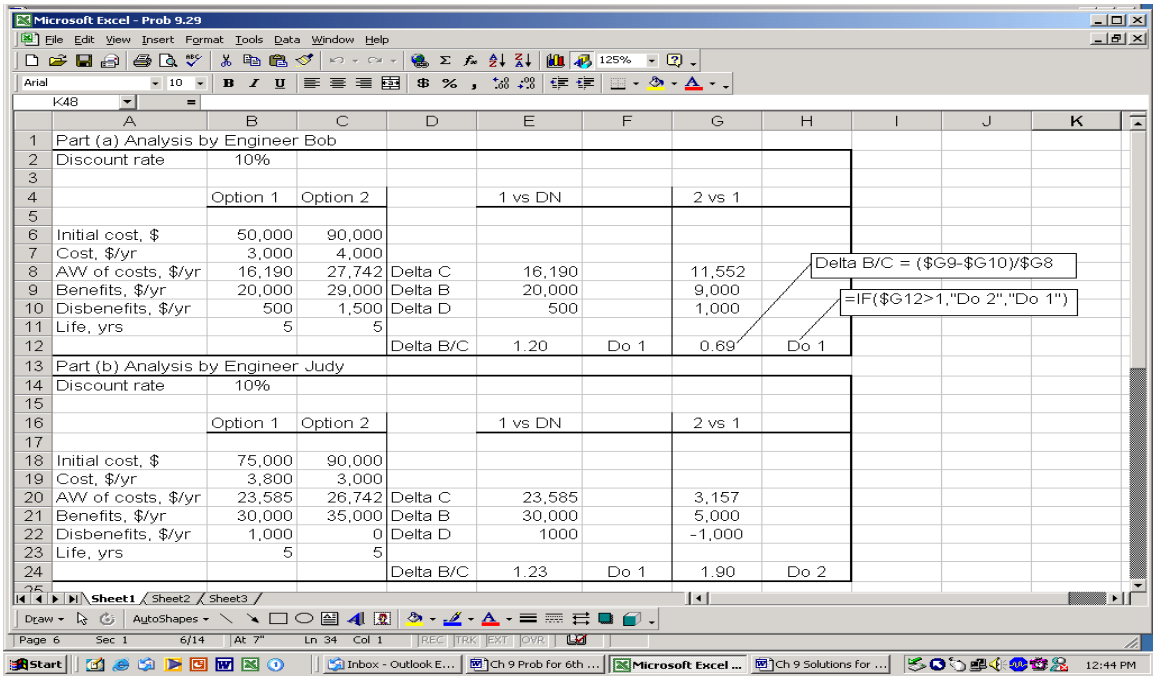
.
W is not justified; select location E.

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

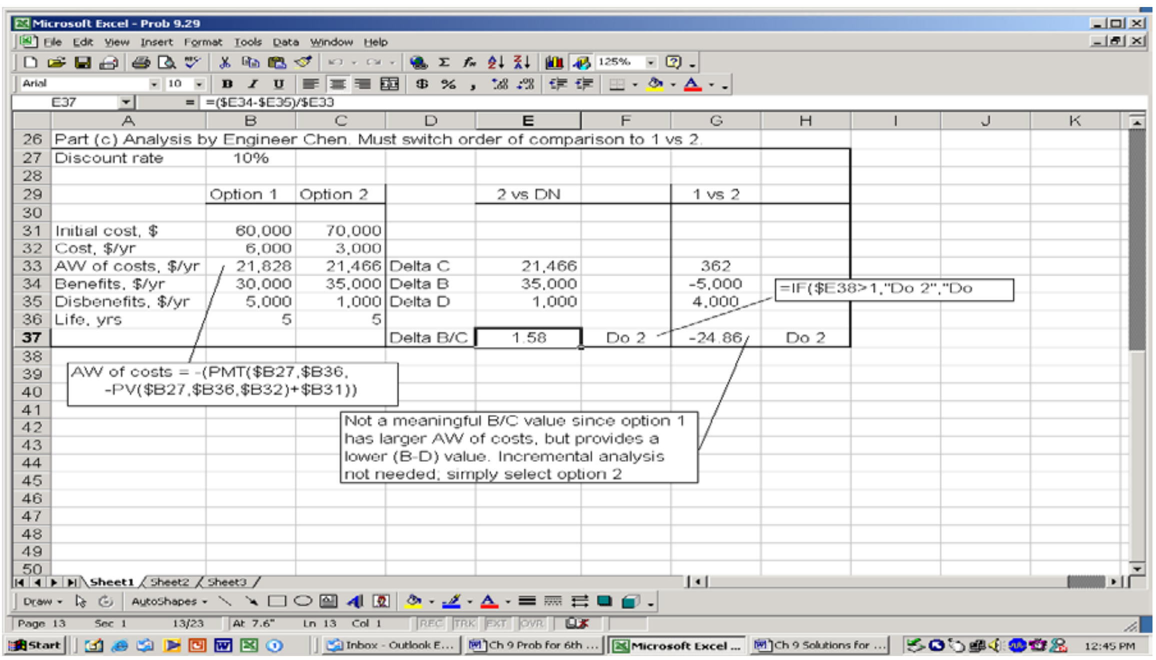
(c) Chen: Compare 2 vs. DN, then 1 vs. 2. Select option 2 without doing the ΔB/C analysis, since benefits minus disbenefits for 1 are less, but this option has a larger AW of costs than option 2.



	A	B	C	D	E	F	G	H
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")



E37 = =($E34-$E35)/$E33

	A	B	C	D	E	F	G	H
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

=IF($E38>1,"Do 2","Do

AW of costs = -(PMT($B27,$B36, -PV($B27,$B36,$B32)+$B31))

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

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

B vs. D: $\Delta B/C = (55 - 52)/(50 - 43)$
$= 0.43$ Eliminate B

C vs. D: $\Delta B/C = (76 - 52)/(72 - 43)$
$= 0.83$ Eliminate C

F vs. D: $\Delta B/C = (84 - 52)/(81 - 43)$
$= 0.84$ Eliminate F

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) $B/C_{Good} = (15{,}000 - 6{,}000)/(10{,}000 - 1{,}500)$
$= 1.06$

$B/C_{Better} = (11{,}000 - 1{,}000)/(8{,}000 - 2{,}000)$
$= 1.67$

$B/C_{Best} = (25{,}000 - 20{,}000)/(20{,}000 - 16{,}000)$
$= 1.25$

$B/C_{Best\ of\ all} = (42{,}000 - 32{,}000)/(14{,}000 - 3{,}000)$
$= 0.91$

Select Good, Better, and Best

(b) Rank acceptable alternatives in terms of increasing FW of net cost

Best: 20,000 – 16,000 = $4,000

Better: 8,000 – 2,000 = $6,000

Good: 10,000 – 1,500 = $8,500

Better vs. Best: $\Delta B/C = [(11{,}000 - 1{,}000) - (25{,}000 - 20{,}000)]/(6{,}000 - 4{,}000)$
$= 2.5$ Eliminate Best

Good vs. Better: $\Delta B/C = [(15{,}000 - 6{,}000) - (11{,}000 - 1{,}000)]/(8{,}500 - 6{,}000)$
< 0 Eliminate Good

Select Better

9.43 Ranking: DN, A, C, E, F, B, D

A vs. DN: $B/C = 1.23 > 1.0$ Eliminate DN

Eliminate C, D, and E because $B/C < 1.0$

F vs. A: $\Delta B/C = 1.02 > 1.0$ Eliminate A

B vs. F: $\Delta B/C = 1.20 > 1.0$ Eliminate F

Select B

9.44 Ranking is A, B, C, D. Eliminate A because $B/C < 1.0$

B vs. DN: $B/C = 1.18$ Eliminate DN

C vs. B: $\Delta B/C = 0.58$ Eliminate C

D vs. B: $\Delta B/C = 1.13$ Eliminate B

Select D

9.45 (a) PW of B_J: $1.05 = (B - 1)/20$
$B = 22$

PW of D_K: $1.13 = (28 - D)/23$
$D = 2$

PW of B/C_L: $(B - D)/C = (35 - 3)/28 = 1.14$

PW of C_M: $1.34 = (51 - 4)/C$
$C = 35$

Incremental B/C calculations

K vs. J: $\Delta B/C = [(28 - 2) - (22 - 1)]/(23 - 20)$
$= 1.67$

L vs. J: $\Delta B/C = [(35 - 3) - (22 - 1)]/(28 - 20)$
$= 1.38$

M vs. J: $\Delta B/C = [(51 – 4) – (22 – 1)]/(35 – 20)$
$= 1.73$

L vs. K: $\Delta B/C = [(35 – 3) – (28 – 2)]/(28 – 23)$
$= 1.20$

M vs. K: $\Delta B/C = [(51 - 4) – (28 – 2)]/(35 – 23)$
$= 1.75$

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.

$CER_A = 5.20/50 = 0.10$
$CER_B = 23.40/182 = 0.13$
$CER_C = 3.75/40 = 0.09$
$CER_D = 10.80/75 = 0.14$
$CER_E = 8.65/53 = 0.16$
$CER_F = 15.10/96 = 0.16$

	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.

$CER_{Acupuncture}$ = 700/ 9 = 78
$CER_{Subliminal}$ = 150/1 = 150
$CER_{Aversion}$ = 1700/10 = 170
$CER_{Out\text{-}patient}$ = 2500/39 = 64
$CER_{In\text{-}patient}$ = 1800/41 = 44
CER_{NRT} = 1300/20 = 65

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	Acupunture	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) CER_W = 355/20 = 17.8
CER_X = 208/17 = 12.2
CER_Y = 660/41 = 16.1
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.

X to Z: $\Delta C/E = (208 - 102)/(17 - 7) = 10.6 < 14.6$

Z is dominated; eliminate Z

W to X: $\Delta C/E = (355 - 208)/(20 - 17) = 49 > 12.2$

Keep W and X; W is new defender

Y to W: $\Delta C/E = (660 – 355)/41 – 20) = 14.5 < 17.8$

W is dominated; eliminate W

Only X and Y remain.

Y 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 ΔC/ analysis.

E = 5; Friend: C/E = 10/5 = 2
E = 10; Slides: C/E = 20/10 = 2
E = 15; TA: C/E = 15/15 = 1
E = 15; Professor: C/E = 20/15 = 1.33

Friend vs. DN: C/E = 2 Basis for comparison

Slides vs. friend: $\Delta C/E = (20-10)/(10-5) = 2$

No dominance; keep both; slides is new defender

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.

$\Delta C/E = (20-15)/(15-15) =$ undefined

Only TA and friend remain.

TA vs. friend: $\Delta C/E = (15-10)/(15-5) = 0.5 < C/E = 2$ 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)

9.61 B/C = (50,000 – 27,000)/[250,000(0.10) + 10,000]
= 0.66

Answer is (b)

9.62 B/C = (60,000 – 29,000 – 15,000)/20,000 = 0.8

Answer is (c)

9.63 Answer is (d)

9.64 1.5 = 50,000/(0.10P + 10,000)
P = $233,333

Answer is (d)

9.65 Answer is (b)

9.66 ΔC/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: ΔB/C = (889,200-744,000)/(773,752-589,566) = 0.79 — eliminate X

Y vs. Z: ΔB/C = (1,111,500-744,000)/(1,179,131-589,566) = 0.62 — eliminate Y

W vs. Z: ΔB/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: ΔC/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 = (difference)(6000)
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 the 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 million/(1 – 0.207)

= $9.08 million

10.5 0.29 = 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 + 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.

Total amount of financing = 18,000,000/0.45
= $40,000,000

10.9 D-E mix: Debt = 12 + 20 = $32 million
Equity = 5 + 10 = $15 million

% debt = 32/(32 + 15) = 68%
% equity = 15/47 = 32%

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

Engineering: FW = 25,000(1) + 25,000(F/P,7%,1)
= 25,000(1 + 1.07)
= $51,750

Two checks: $25,000 to parents and $26,750 to credit union

(c) Business: 4%

Engineering: 0.5(0%) + 0.5(7%) = 3.5%

10.11 First Engineering: Fraction debt = 87/175 ≈ 50%

Fraction equity = (175-87)/175 ≈ 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

WACC = (3/13)(0.15) + (4/13)(0.09) + (6/13)(0.07)
= 9.46%

10.14 (a) WACC_1 = 0.5(9%) + 0.5(6%) = 7.5%

WACC_2 = 0.2(9%) + 0.8(8%) = 8.2%

Plan 1 has a lower WACC

(b) Let x = cost of debt capital

WACC_1 = 8.2% = 0.5(9%) + 0.5x
x = 7.4%

WACC_2 = 8.2% = 0.2(9%) + 0.8x
x = 8.0%

Plan 1 cost of debt goes up from 6% to 7.4%; Plan 2 maintains the same cost.

10.15 WACC = cost of debt capital + 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

WACC = 11.1% = 0.75(7%) + (1- 0.75)(x)
x = (11.1 – 5.25)/0.25
= 23.4%

10.17 (a) Determine the after-tax cost of debt capital, Equation [10.4], and WACC

After-tax cost of debt capital = 10(1 - 0.36) = 6.4%
After-tax WACC = 0.35(6.4%) + 0.65(14.5%) = 11.665%

Interest charged to revenue for the project:

14.0 million(0.11665) = $1,633,100

(b) After-tax WACC = 0.25(14.5%) + 0.75(6.4%)
= 8.425%

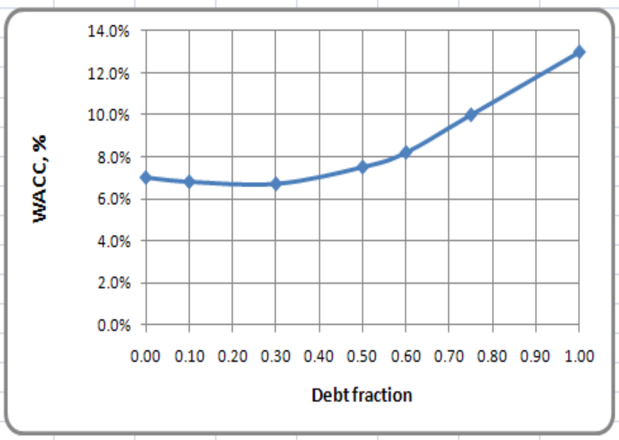
Interest charged to revenue for the project:

14.0 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.

Equity rate of earnings =			7%
Equity fraction	Debt fraction	Estimated loan interest rate, %	WACC, %
1.00	0.00	0.0%	7.0%
0.90	0.10	5.0%	6.8%
0.70	0.30	6.0%	6.7%
0.50	0.50	8.0%	7.5%
0.40	0.60	9.0%	8.2%
0.25	0.75	11.0%	10.0%
0.00	1.00	13.0%	13.0%



10.19 (a) Compute and plot WACC for each D-E mix. See plot in problem 10.20 below.

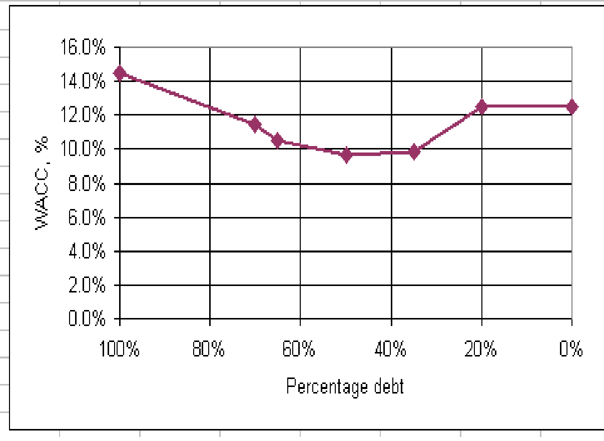
D-E mix	WACC
100-0	14.50%
70-30	11.44
65-35	10.53
50-50	9.70
35-65	9.84
20-80	12.48
0 - 100	12.50

(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%.

D-E Mix	Debt %	Debt rate %	Equity %	Equity rate %	WACC
100 - 0	100%	0.145	0%	0%	14.50%
70 - 30	70%	0.13	30%	0.078	11.44%
65 - 35	65%	0.12	35%	0.078	10.53%
50 - 50	50%	0.115	50%	0.079	9.70%
35 - 65	35%	0.099	65%	0.098	9.84%
20 - 80	20%	0.124	80%	0.125	12.48%
0 - 100	0%	0	100%	0.125	12.50%

=(B9*C9) + (D9*E9)

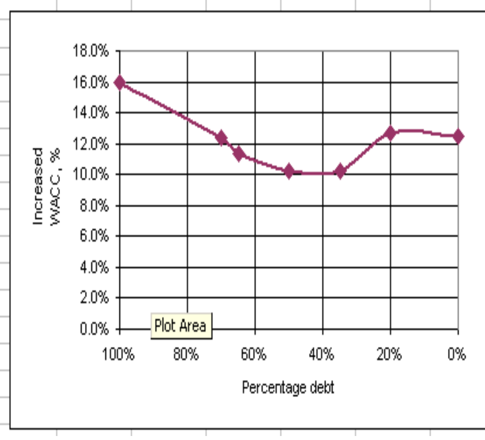


(b) Multiply the debt rate (column C) by 1.1 to add the 10% (column D) and observe the new plot. Now debt of 35% (D-E of 35-65) has the lowest WACC = 10.18%.

D-E Mix	Debt %	Debt rate %	10% Increased Debt Rate %	Equity %	Equity rate %	Increased WACC
100 - 0	100%	0.145	0.1595	0%	0%	15.95%
70 - 30	70%	0.13	0.143	30%	0.078	12.35%
65 - 35	65%	0.12	0.132	35%	0.078	11.31%
50 - 50	50%	0.115	0.1265	50%	0.079	10.28%
35 - 65	35%	0.099	0.1089	65%	0.098	10.18%
20 - 80	20%	0.124	0.1364	80%	0.125	12.73%
0 - 100	0%	0	0	100%	0.125	12.50%

=C8*1.1

=(B9*D9) + (E9*F9)



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

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*/year = 2(2.04) = 4.08% per year

(b) Effective i*/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

$$(A/P,i^*,8) = \frac{123,525}{800,000} = 0.15441$$

$i^* = 4.95\%$ (RATE function)

Bond issue

Annual bond dividend = 800,000(0.06) = $48,000
Tax saving = 48,000(0.40) = $19,200
Effective bond dividend = 48,000 – 19,200 = $28,800

The AW-based i* relation is:

$$0 = 800,000(A/P,i^*,10) - 28,800 - 800,000(A/F,i^*,10)$$

$i^* = 3.60\%$ (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.

Debt cost of capital: before-tax $(1-T_e)$ = 9%(1- 0.22) = 7.02%
Annual interest 160,000(0.0702) = $11,232
Annual principal re-payment = 160,000/15 = $10,667
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:

Difference = 200,000 - PW equity lost – PW of loan interest paid
– PW of loan principal re-payment not saved as equity
= $-26, 916

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%)		Difference
3	Year		Lost interest CF	Loan interest CF	Prin repay CF	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 (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.

Equity WACC = retained earnings fraction (cost) + stock fraction (cost)
= 4/15(7.4%) + 6/15(4.8%)
= 3.893%

Debt WACC = 5/15(9.8%) = 3.267%

WACC = 3.893 + 3.267 = 7.16%

MARR = WACC + 4%
= 7.16 + 4.0
= 11.16%

(b) Debt capital gets a tax break; equity does not.

After-tax cost of debt = 9.8%(1- 0.32) = 6.664%

After-tax WACC = equity cost + debt cost
= 4/15(7.4%) + 6/15(4.8%) + 5/15(6.664%)
= 6.11%

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 *<u>100% equity financing</u>*

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

<u>60%-40% D-E financing</u>

$$\begin{aligned} \text{Loan principal} &= 250{,}000(0.60) = \$150{,}000 \\ \text{Loan payment} &= 150{,}000(A/P,7\%,15) \\ &= 150{,}000(0.10979) \\ &= \$16{,}469 \text{ per year} \end{aligned}$$

Cost of 60% debt capital is 7% for the loan.

$$\begin{aligned} WACC = 0.4(7.5\%) + 0.6(7\%) &= 7.2\% \\ MARR &= 7.2\% \end{aligned}$$

$$\begin{aligned} \text{Annual NCF} &= \text{project NCF - loan payment} \\ &= \$30{,}000 - 16{,}469 = \$13{,}531 \end{aligned}$$

Amount of equity invested = 250,000 - 150,000 = $100,000

Calculate PW at the MARR on the basis of the committed equity capital.

$$PW = -100,000 + 13,531(P/A,7.2\%,15)$$
$$= -100,000 + 13,531(8.99397)$$
$$= \$21,697$$

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% (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

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%

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

After-tax debt i* = $[(1 + 0.05/4)^4 - 1]$ (1- 0.3) (100%)
= 5.095(0.7) = 3.566% per year

WACC = 0.4(7.5%) + 0.6(3.566%) = 5.14% per year

MARR = 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)				

=-PMT($C$1,5,NPV($C$1,C6:C10)+C5)

=IRR(C$5:C$10)

=-PMT($D$1,5,NPV($D$1,C$6:C$10)+C$5)

(a) At 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 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 $\Sigma s_i = 60 + 40 + 80 + 30 + 20 = 230$

$W_1 = 60/230 = 0.26$
$W_2 = 40/230 = 0.17$
$W_3 = 80/230 = 0.35$
$W_4 = 30/230 = 0.13$
$W_5 = 20/230 = 0.09$ (Sum is 1.00)

10.44 S = 1 + 2 + 3 +… + 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 = ½ F = 50
S = 0.7 U = 0.7(50) = 35
R = 2S = 2(35) = 70

Attribute	Importance Score
F	100
S	35
U	50
R	70
	255

Weighting, W_i = Score/255

Attribute	W_i
F	0.39
S	0.14
U	0.20
R	0.27
	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

Attribute	Importance
1	9
2	1
3	3
4	6
5	10
6	4.8
	33.8

Weighting, W_i = Score/33.8

Attribute	W_i
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	V_{ij} values 1	2	3	
1	20	0.10	5	7	10	
2	80	0.40	40	24	12	
3	100	0.50	50	20	25	
	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	V_{ij} values 1	2	3	
1	100	0.50	25	35	50	
2	80	0.40	40	24	12	
3	20	0.10	10	4	5	
	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	R_j 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	20	0.12	0.03	0.12
	165		0.76	0.92

Therefore, select B

(c) Calculate R_j and use *trainer* scores for attributes.

Attribute i	Importance (by trainer)	W_i	R_j A	R_j B
1	80	0.26	0.26	0.23
2	80	0.26	0.09	0.26
3	100	0.32	0.32	0.29
4	50	0.16	0.04	0.16
	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)

10.57 $\Sigma s_i = 55 + 45 + 85 + 30 + 60 = 275$

$W_1 = 55/275 = 0.20$

Answer is (b)

10.58 $S = 1 + 2 + 3 + \ldots + 8 = 8(9)/2 = 36$

$W_C = 6/36 = 0.166$

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

WACC = (% equity)(cost of equity) + (% debt)(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].

Tax savings = interest(tax rate)
= [loan payment – principal portion](tax rate)

Loan payment = 750,000(A/P,8%,10) = $111,773 per year
Interest = 111,773 – 75,000 = $36,773
Tax savings = (36,773)(0.35) = $12,870

Cost of debt capital is i* from a PW relation:

0 = loan amount – (annual payment after taxes)(P/A,i*,10)
= 750,000 – (111,773 – 12,870)(P/A,i*,10)

(P/A,i*,10) = 750,000 / 98,903 = 7.5832

i* = 5.37% (RATE function)

Plan A (50-50): MARR = $WACC_A$ = 0.5(5.37) + 0.5(8.33) = 6.85%

Plan B (0-100%): MARR = $WACC_B$ = 8.33%

2. A: 50–50 D–E financing

Use relations in case study statement and the results from Question #1.

TI = 300,000 – 36,773 = $263,227
Taxes = 263,227(0.35) = $92,130
After-tax NCF = 300,000 – 75,000 – 36,773 – 92,130
= $96,097

Find plan i_A* from AW relation for $750,000 of equity capital

$0 = \text{(committed equity capital)}(A/P,i_A^*,n) + S(A/F, i_A^*,n) + \text{after tax NCF}$

$0 = -750{,}000(A/P,i_A^*,10) + 200{,}000(A/F,i_A^*,10) + 96{,}097$

$i_A^* = 7.67\%$ (RATE function)

Since $7.67\% > WACC_A = 6.85\%$, plan A is acceptable.

B: <u>0–100 D–E financing</u>

Use relations is the case study statement

After tax NCF = 300,000(1–0.35) = $195,000

All $1.5 million is committed. Find i_B^*

$0 = -1{,}500{,}000(A/P,i_B^*,10) + 200{,}000(A/F,i_B^*,10) + 195{,}000$

$i_B^* = 6.61\%$ (RATE function)

Now $6.61\% < WACC_B = 8.33\%$, plan B is rejected.

Recommendation: Select plan A with 50-50 financing.

3. 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.

Question #3 (The hard way)

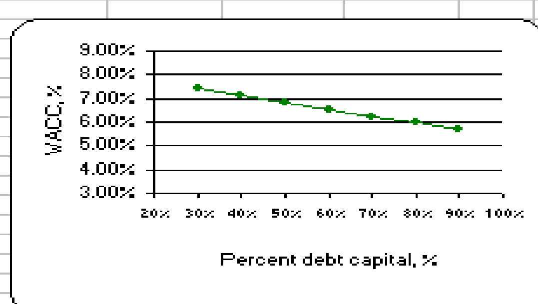
Capital investment	$ 1,500,000
Cost of equity capital	8.33%
Tax rate	35%

% debt	Loan amount	Loan payment	Interest amount (Cost of debt capital)	Tax savings	Loan cash flow	Cost of debt	WACC
0.00001%	$ 0.15	$ 0.02	$ 0.01	$ 0.00	$ 0.02	5.37%	8.33%
30%	$ 450,000	$ 67,063	$ 22,063	$ 7,722	$ 59,341	5.37%	7.44%
40%	$ 600,000	$ 89,418	$ 29,418	$ 10,296	$ 79,122	5.37%	7.15%
50%	$ 750,000	$ 111,772	$ 36,772	$ 12,870	$ 98,902	5.37%	6.85%
60%	$ 900,000	$ 134,127	$ 44,127	$ 15,444	$ 118,682	5.37%	6.56%
70%	$ 1,050,000	$ 156,481	$ 51,481	$ 18,018	$ 138,463	5.37%	6.26%
80%	$ 1,200,000	$ 178,835	$ 58,835	$ 20,592	$ 158,243	5.37%	5.97%
90%	$ 1,350,000	$ 201,190	$ 66,190	$ 23,166	$ 178,023	5.37%	5.67%

Question #3 (The easy way)

Cost of debt capital =	5.37%
Cost of equity capital =	8.33%

% debt	WACC
0%	8.33%
30%	7.44%
40%	7.15%
50%	6.85%
60%	6.55%
70%	6.26%
80%	5.96%
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

Sunk cost = 40,000 – 15,000
= $25,000

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.

Sunk cost = 115,000 – 126,000
= $11,000

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 = market value = $39,000
AOC = $17,000 per year
n = 3 years
S = $23,000

11.6 (a) P = 90,000 – 8000(2) = $74,000
S = 90,000 – 8000(3) = $66,000
AOC = $65,000 per year

(b) P = 90,000 – 8000(3) = \$66,000
S = 90,000 – 8000(4) = \$58,000
AOC = \$65,000 per year

11.7 P = 7000 + 17,000 = \$24,000
S = \$12,000
AOC = \$27,000 per year
n = 3 years

11.8 AW_1 = -10,000(A/P,10%,1) – 1000 + 7000(A/F,10%,1) = \$-5000
AW_2 = -10,000(A/P,10%,2) – 1000(P/F,10%,1)(A/P,10%,2)
+ (5000 – 1200)(A/F,10%,2) = \$-4476
AW_3 = -10,000(A/P,10%,3) – [1000(P/F,10%,1) +1200(P/F,10% 2)](A/P,10%,3)
+ (4500 – 1300)(A/F,10%,3) = **\$-3819**
AW_4 = -10,000(A/P,10%,4) – [1000(P/F,10%,1) +1200(P/F,10% 2)
+ 1300(P/F,10%,3)](A/P,10%,4) + (3000 – 2000)(A/F,10%,4) = \$-3847
AW_5 = -10,000(A/P,10%,5) – [1000(P/F,10%,1) + 1200(P/F,10% 2)
+ 1300(P/F,10%,3) + 2000(P/F,10%,4)](A/P,10%,5)
+ (2000 – 3000)(A/F,10%,5) = \$-3921

ESL is 3 years with AW = \$-3819 per year

11.9 (a) Find total AW for each year of ownership

AW_1 = -345,000(A/P,10%,1) – 148,000 + 140,000(A/F,10%,1) = \$-387,500
AW_2 = -345,000(A/P,10%,2) – 148,000 + 140,000(A/F,10%,2) = \$-280,119
AW_3 = -345,000(A/P,10%,3) – 148,000 + 140,000(A/F,10%,3) = **\$-244,434**
AW_4 = -345,000(A/P,10%,4) – 148,000(P/A,10%,3)(A/P,10%,4)
-210,000(P/F,10%,4)(A/P,10%4) = \$-270,197
AW_5 = -345,000(A/P,10%,5) – 148,000(P/A,10%,3)(A/P,10%,5)
-210,000(P/A,10%,2)(P/F,10%,3)(A/P,10%,5) = \$-260,337
AW_6 = -345,000(A/P,10%,5) – 148,000(P/A,10%,3)(A/P,10%,6)
-210,000(P/A,10%,3)(P/F,10%,3)(A/P,10%,6) = \$-253,813

ESL is 3 years with AW = \$-244,434

(b) If retained 5 years, AW = \$260,337 per year, which is a 6.5% increase

Percent increase = (260,337 - 244,434)/244,434 = 0.065 (6.5%)

11.10 For P: 18,899 = P(A/P,10%,3)
18,899 = P(0.40211)
P = \$47,000

For S: $6648 = S(A/F,10\%,3)$
$6648 = S(0.30211)$
$S = \$22,005$

11.11 Amortization of a \$70,000,000 investment at 8% per year is constant at \$-5,600,000. Therefore, only consider maintenance cost:

$AW_1 = -83,000(A/F,8\%,1) = \$-83,000$
$AW_2 = -91,000(A/F,8\%,2) = \$-43,750$
$AW_3 = -125,000(A/F,8\%,3) =$ **\$-38,504**
$AW_4 = -183,000(A/F,8\%,4) = \$-40,612$

Lowest AW is for 3 years; maintenance should be scheduled at 3-year intervals

11.12 $AW_1 = -65,000(A/P,10\%,1) – 50,000 + 30,000(A/F,10\%,1) = \$-91,500$
$AW_2 = -65,000(A/P,10\%,2) – [50,000 + 10,000(A/G,10\%,2)] + 30,000(A/F,10\%,2)$
= **\$-77,929**
$AW_3 = -65,000(A/P,10\%,3) – [50,000 + 10,000(A/G,10\%,3)] + 20,000(A/F,10\%,3)$
$= \$-79,461$
$AW_4 = -65,000(A/P,10\%,4) – [50,000 + 10,000(A/G,10\%,4)] + 20,000(A/F,10\%,4)$
$= \$-80,008$
$AW_5 = -65,000(A/P,10\%,5) – [50,000 + 10,000(A/G,10\%,5)] + 20,000(A/F,10\%,5)$
$= \$-81,972$
$AW_6 = -65,000(A/P,10\%,6) – [50,000 + 10,000(A/G,10\%,6)] + 20,000(A/F,10\%,6)$
$= \$-84,568$
$AW_7 = -65,000(A/P,10\%,7) – [50,000 + 10,000(A/G,10\%,7)] + 20,000(A/F,10\%,7)$
$= \$-87,459$

ESL is 2 years with AW = \$-77,929

11.13 (a) Use 1 year and AW of first cost P

$-88,000 = -80,000(A/P,i,1)$
$(A/P,i,1) = 1.1000$

From tables, i = 10% per year

(b) $-78,762 = -46,095 – 46,000 + \text{AW of S}$
AW of S = $13,333 = S(A/F,10\%,2)$
$13,333 = S(0.47619)$
$S = \$27,999$ (basically, \$28,000)

11.14 $AW_1 = -70,000(A/P,12\%,1) – 75,000 + 59,500(A/F,12\%,1) = \$-93,900$
$AW_2 = -70,000(A/P,12\%,2) – 75,000 + 50,575(A/F,12\%,2) = \$-92,563$
$AW_3 = -70,000(A/P,12\%,3) – 75,000 + 42,989(A/F,12\%,3) = \$-91,405$
$AW_4 = -70,000(A/P,12\%,4) – 75,000 + 36,540(A/F,12\%,4) = \$-90,401$

AW_5 = -70,000(A/P,12%,5) – 75,000 + 31,059(A/F,12%,5) = $-89,530
AW_6 = -70,000(A/P,12%,6) – 75,000 + 26,400(A/F,12%,6) = **$-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 + 10000(A/G,15%,2)]
+ 80,000(A/F,15%,2) = $-129,709

AW_3 = **$-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)	

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

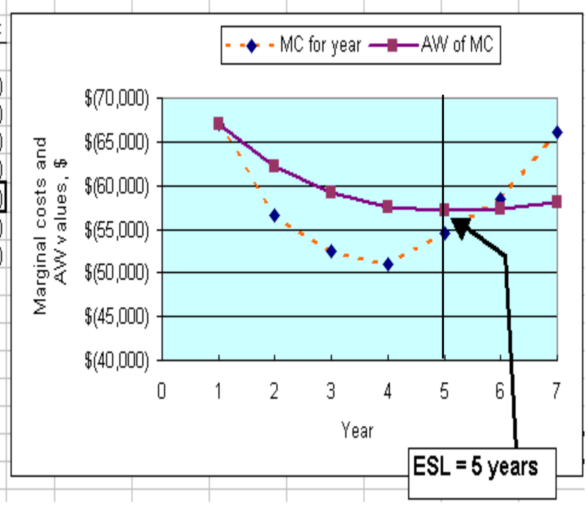
AW_2 = -100,000(A/P,14%,2) - [28,000(P/F,14%,1) + 31,000
(P/F,14%,2)] (A/P,14%,2) + 60,000(A/F,14%,2)
= $-62,093

AW_3 = $-59,275
AW_4 = $-57,594
AW_5 = **$-57,141**
AW_6 = $-57,300
AW_7 = $-58,120

Economic service life is 5 years with AW = $-57,141per year

11.17 Spreadsheet and marginal costs used to find the ESL of 5 years with AW = $-57,141

Year	Market value	Loss in MV for year	Lost interest MV for year	AOC	MC for year	AW of MC
0	$100,000					
1	$ 75,000	$ 25,000	$ 14,000	$28,000	$ (67,000)	$ (67,000)
2	$ 60,000	$ 15,000	$ 10,500	$31,000	$ (56,500)	$ (62,093)
3	$ 50,000	$ 10,000	$ 8,400	$34,000	$ (52,400)	$ (59,275)
4	$ 40,000	$ 10,000	$ 7,000	$34,000	$ (51,000)	$ (57,594)
5	$ 25,000	$ 15,000	$ 5,600	$34,000	$ (54,600)	$ (57,141)
6	$ 15,000	$ 10,000	$ 3,500	$45,000	$ (58,500)	$ (57,300)
7	$ -	$ 15,000	$ 2,100	$49,000	$ (66,100)	$ (58,120)



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.

	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.

11.21 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

AW_C = -270,000(A/P,20%,10) + 50,000(A/F,20%,10)
= -270,000(0.23852) + 50,000(0.03852)
= $-62,474

Select the defender; upgrade rooms and plan to keep them for 4 years.

11.22 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

11.23 AW_C = -26,000(A/P,10%,5) –1200 + 8000(A/F,10%,5)
= \$-6748

AW_1 = -5000(A/P,10%,1) – 1900 + 3000(A/F,10%,1)
= \$-4400
AW_2 = -5000(A/P,10%,2) – [1900 + 200(A/G,10%,2)] + 2500(A/F,10%,2)
= \$-3686
AW_3 = -5000(A/P,10%,3) – [1900 + 200(A/G,10%,3)] + 2200(A/F,10%,3)
= \$-3433

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.

11.24 AW_D = -25,000(A/P,15%,5) - 180,000
= \$-187,458

AW_C = -700,000(A/P,15%,10) – 70,000 + 50,000(A/F,15%,10)
= \$-207,014

Select the defender; retain the current process

11.25 AW_{D1} = -(8000 + 43,000)(A/P,10%,1) – 22,000 + 8000(A/F,10%,1)
= \$-70,100

AW_{D2} = -(8000 + 43,000)(A/P,10%,2) – 22,000(P/F,10%,1)(A/P,10%,2)
+ (8000 – 25,000)(A/F,10%,2)
= \$-49,005

AW_C = \$-47,063

The company should replace the existing machine *now*.

11.26 Defender estimates have changed; determine the ESL for the defender

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

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

ESL is 2 years with AW_D = \$-65,333

AW_C = \$-56,000

The company should outsource the process now

11.27 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

11.28 Find AW of defender for keeping one or two more years and compare against AW of challenger

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

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

AW_C = -138,000(A/P,10%,5) - 9000 + 32,000(A/F,10%,5)
= -138,000(0.26380) - 9,000 + 32,000(0.16380)
= $-40,163

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:

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

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

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

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

11.30 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

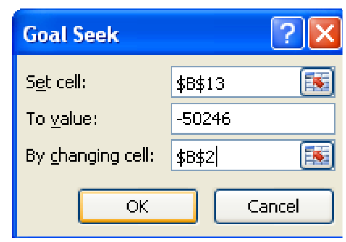
AW_C = -300,000(A/P,12%,10) + 50,000(A/F,12%,10)
= -300,000(0.17698) + 50,000(0.05698)
= $-50,245

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



11.32 (a) By hand: Find ESL of the defender; compare with AW_C over 5 years.

AW_{D1} = -8000(A/P,15%,1) – 50,000 + 6000(A/F,15%,1)
= -8000(1.15) – 44,000
= $-53,200

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

AW_{D3} = -8000(A/P,15%,3) - [50,000(P/F,15%,1) + 53,000(P/F,15%,2)](A/P,15%,3) + (-60,000 + 1000)(A/F,15%,3)
= -8000 (0.43798) - [50,000(0.8696) + 53,000(0.7561)] (0.43798) -59,000(0.28798)
= -$57,089

The ESL is now 1 year with AW_{D1} = $-53,200

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

Since the ESL AW_{D1} value is lower that 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
1	i =	15%						
2	P =	$8,000						
3				**Defender Analysis**		=PMT($B$1,$A6,$B$2,-$B6)		
4		Market						
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW	=D6 + E6	
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						=-PMT($B$1,$A8,NPV($B$1,$C$6:$C8)+0)		
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:

PW defender for 3 years = $-27,000(P/A,10%,3)
= $-27,000(2.4869)
= $-67,146

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

PW defender for 1, challenger for 2 = -22,000(P/F,10%,1)
- 26,000(P/A,10%,2)(P/F,10%,1)
= -22,000(0.9091) - 26,000(1.7355)(0.9091)
= $-61,022

PW challenger for 3 years = $-25,000(P/A,10%,3)
= $-25,000(2.4869)
= $-62,173

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

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

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

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

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

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

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

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.

11.38 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

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

Purchase robot X

11.39 (a) 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

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

Keep the presently-owned machine and replace it in 3 years

(b) n = 3 years: CR = -220,000(A/P,15%,3) + 50,000(A/F,15%,3)
= -220,000(0.43798) + 50,000(0.28798)
= $-81,957

n = 8 years: CR = -220,000(A/P,15%,8) + 10,000(A/F,15%,8)
= -220,000(0.22285) + 10,000(0.07285)
= $-48,299

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

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

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

Process K is selected

(b) For 3-year study period, must re-purchase K for only 1 year.

AW_K = -165,000(A/P,12%,3) – 69,000
+ (-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)
+ 50,000(0.29635)
= $-164,370

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

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.

n = 6 years: CR = -38(A/P,15%,6) + 5.93(A/F,15%,6)
= -38(0.26424) + 5.93(0.11424)
= $-9.36 ($-9.36 million)

n = 12 years: CR = -38(A/P,15%,12) + 1.06(A/F,15%,12)
= -38(0.18448) + 1.06(0.03448)
= $-6.97 ($-6.97 million)

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 5^{th} 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%				alues are i						(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 -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 RV = 135,771
RV = $326,098

11.44 -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 RV = 2483
RV = $5964

11.45 -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 RV = 20,626
RV = $35,797

11.46 -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 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:

Projects	Investment
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

$PW_{I,II}$ = -55,000 + 15,000(P/A,15%,4) + 3000(P/F,15%,4)
= -55,000 + 15,000(2.8550) + 3000(0.5718)
= $-10,460

(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:*

Sample calculation: $PW_{A,B}$ = -45,000 + 15,000(P/A,15%,4)
+ 4000(P/F,15%,4)
= -45,000 + 15,000(2.8550) + 4000(0.5718)
= $112

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 (not acceptable)

By spreadsheet, enter the following to display the project PW values.

A: = -PV(10%,8,360000)-1500000 Display: $420,573
B: = -PV(10%,10,600000)-3000000 Display: $686,740
C: = -PV(10%,5,620000)-1800000 Display: $550,288
D: = -PV(10%,4,630000)-2000000 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 $ Million	PW, $
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 $ Million	PW, $
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_{diag} = -45,000 + 2200(P/A,0.5%,36) = $27,316
PW_{exh} = -30,000 + 2000(P/A,0.5%,36) = $35,742
PW_{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

PW_A = -100,000 + 50,000(P/A,10%,8)
= -100,000 + 50,000(5.3349)
= $166,746

PW_B = -125,000 + 24,000(P/A,10%,8)
= -125,000 + 24,000(5.3349)
= $3038

PW_C = -120,000 + 75,000(P/A,10%,8)
= -120,000 + 75,000(5.3349)
= $280,118

PW_D = -220,000 + 39,000(P/A,10%,8)
= -220,000 + 39,000(5.3349)
= $-11,939

PW_E = -200,000 + 82,000(P/A,10%,8)
= -200,000 + 82,000(5.3349)
= $237,462

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	1,026060
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.

Reduced NCF after Goal Seek solution

	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, $ 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.

$$PW_E = -21{,}000 + 9500(P/A,15\%,9)$$
$$= -21{,}000 + 9500(4.7716)$$
$$= \$24{,}330$$

The linear programming formulation is:

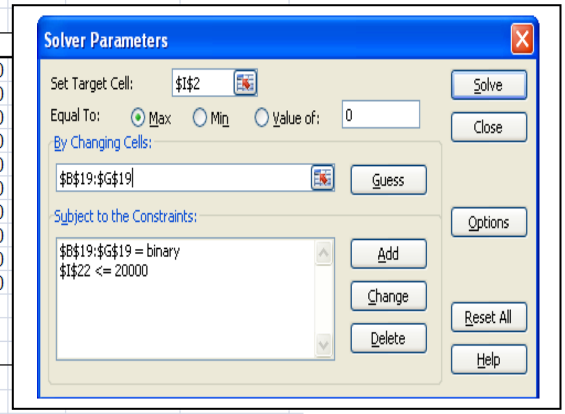
$$\text{Maximize } Z = 3694x_1 - 1019\,x_2 + 4788\,x_3 + 6120\,x_4 + 24{,}330\,x_5$$

$$\text{Constraints: } 10{,}000x_1 + 15{,}000\,x_2 + 8000\,x_3 + 6000\,x_4 + 21{,}000\,x_5 < 20{,}000$$

$$x_k = 0 \text{ or } 1 \text{ for } k = 1 \text{ to } 5$$

(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



(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 ≈ $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,

$$\text{Maximize } Z = 3019x_1 - 523\,x_2 + 874\,x_3 + 804\,x_4$$

$$\text{Constraints: } 5{,}000x_1 + 8{,}000\,x_2 + 9000\,x_3 + 10000\,x_4 < 16{,}000$$

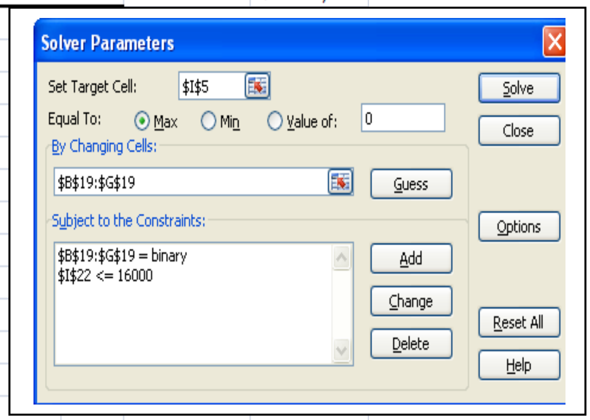
$$x_k = 0 \text{ or } 1 \text{ for } k = 1 \text{ to } 4$$

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

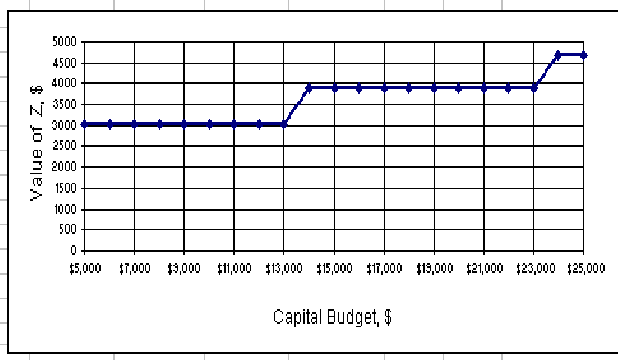
This is the same as in Problem 12.18 where all viable mutually exclusive bundles were evaluated by hand.

	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**



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%

PI = 60,000(P/A,15%,8)/ | -325,000 |
= 60,000(4.4873)/325,000
= 0.83

PW = -325,000 + 60,000(P/A,15%,8)
= -325,000 + 60,000(4.4873)
= $-55,762

(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

(b) Overall ROR = [20,000(20%) + 10,000(19%) + 9,000(13%)]/39,000
= 18.1%

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.

For L: 0 = -30,000 + 9000(P/A,i*,10)
i* = 27.3%

For A: 0 = -15,000 + 4,900(P/A,i*,10)
i* = 30.4%

For N: 0 = -45,000 + 11,100(P/A,i*,10)
i* = 21.0%

For D: 0 = -70,000 + 9000(P/A,i*,10)
i* = 4.9%

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	Sorted by IROR	
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		

(b) 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.

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: $0 = -60{,}000 + 9000(P/A,i,8)$
$i^* = 4.2\%$

Only two projects (W and Y) have rate of return ≥ 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
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

$0 = -57 + 17.1(P/A,i^*,3) + 12.1(P/A,i^*,3)(P/F,i^*,3)$
$i^* = 15.1\%$ (IRR function)

(c) $43 million was not committed; assume it makes MARR = 12% elsewhere.

Overall ROR = [57,000(15.1) + 43,000(12.0)]/100,000
= 13.8%

12.30 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

PW of first cost = 200,000 + 200,000(P/F,10%,1)
= 200,000 + 200,000(0.9091)
= $381,820

PI = 378,426/381,820
= 0.99

12.31 (a) PI_A = 4000(P/A,10%,10)/18,000
= 4000(6.1446)/18,000
= 1.37

PI_B = 2800(P/A,10%,10)/15,000
= 2800(6.1446)/15,000
= 1.15

PI_C = 12,600(P/A,10%,10)/35,000
= 12,600(6.1446)/35,000
= 2.21

PI_D = 13,000(P/A,10%,10)/60,000
= 13,000(6.1446)/60,000
= 1.33

PI_E = 8000(P/A,10%,10)/50,000
= 8000(6.1446)/50,000
= 0.98

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 PI < 1.0

(b)

IROR order	C	A	D	B
Cum Inv, $1000	35	53	113	128

Select C, A, and D; invest a total of $113,000. E is eliminated with 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:

IROR: 54,000/200,000 = 27.0%
PI: [54,000/0.25)]/200,000 = 1.08
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 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 per pound

13.4 France: Q_{BE} = 3.5 million/(8500-3900)
= 761 hwt

US: Q_{BE} = 2.65 million/(12,500-9,900)
= 1019 hwt

13.5 France: Q_{BE} = 761 = 3.5million (1.10)/(r - 3900)

r = 3.85 million/761 + 3900
= $8959 per hwt

US: Q_{BE} = 1019 = 2.65million (1.10)/(r - 9900)

r = 2.915 million/1019 + 9900
= $12,761 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 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 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 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 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

Gasoline cost savings = 3.25/18 – 3.25/21 = $0.0258/mile

800 = 0.0258m(P/A,1%,36)

m = 800/0.0258(30.1075)
= 1030 miles/month

13.11 Added income for equipment from extra charges is

1421 – 758 – 400 = $263 per patient

P = 263(50)(P/A,10%,5)
= 263(50)(3.7908)
= $49,849

13.12 Current cost per mile = 3.50/20 = $0.175 per mile

Friction-reduced cost per mile = 3.50/[(20(1.25)] = $0.140

560(A/P,10%,5) = (0.175 – 0.140)x
560(0.26380) = (0.035)x

0.035x = 147.73
x = 4221 miles per year

13.13 [2.90/18]x miles = (2.98 – 2.90)20
0.161x = 1.60
x = 9.93 miles

13.14 Let G = gradient increase per year. Set revenue = cost

[4000 + G(A/G,12%,3)](33,000 – 21,000) = -200,000,000(A/P,12%,3)
+ (0.20)(200,000,000)(A/F,12%,3)

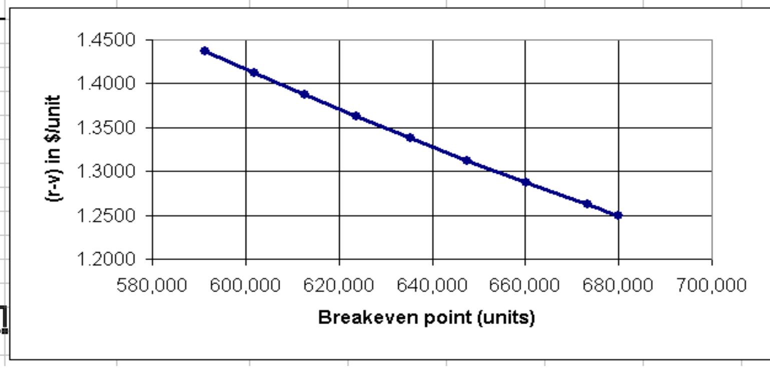
[4000 + G(0.9246)](12,000) = -200,000,000(0.41635)
+ 40,000,000(0.29635)

G = 2110 cars/year increase

13.15 (a) Calculate $Q_{BE} = FC/(r-v)$ for (r-v) increases of 1% through 15% and plot.

Current (r-v) $ 1.25   Current FC $ 850,000

Percent increase in (r-v)	Possible value of (r-v)	Estimated breakeven point (units)
0%	1.2500	680,000
1%	1.2625	673,267
3%	1.2875	660,194
5%	1.3125	647,619
7%	1.3375	635,514
9%	1.3625	623,853
11%	1.3875	612,613
13%	1.4125	601,770
15%	1.4375	591,304



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.

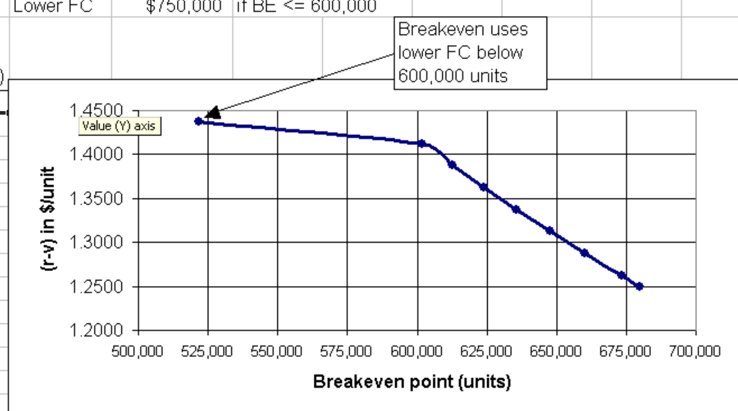
13.16 Rework the spreadsheet above to include an IF statement for the computation of Q_{BE} for the reduced FC of $750,000. The breakeven point falls substantially to 521,739 when the lower FC is in effect.

Current (r-v) $ 1.25   Current FC $ 850,000

Lower FC $750,000 if BE <= 600,000

Percent increase in (r-v)	Possible value of (r-v)	Estimated breakeven point (units)
0%	1.2500	680,000
1%	1.2625	673,267
3%	1.2875	660,194
5%	1.3125	647,619
7%	1.3375	635,514
9%	1.3625	623,853
11%	1.3875	612,613
13%	1.4125	601,770
15%	1.4375	521,739

=IF(($E$2/$B13)>600000,$E$2/$B13,$E$3/$B13)



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

$$-7500\,x = -218{,}000(A/P,6\%,20) – 12{,}000$$
$$-7500\,x = -218{,}000(0.08718) – 12{,}000$$
$$-7500\,x = -31{,}005$$
$$x = 4.1$$

The city could afford four portable toilets per year

13.18 Equate AW relations for the two alternatives

$$P_{HDPE}(A/P,6\%,12) = 1{,}800{,}000(A/P,6\%,6) + 375{,}000(P/F,6\%,4)(A/P,6\%,6)$$
$$P_{HDPE}(0.11928) = 1{,}800{,}000(0.20336) + 375{,}000(0.7921)(0.20336)$$
$$P_{HDPE} = \$3{,}575{,}231$$

13.19 $VC_{excavator}$ = (15 + 1)/0.15 = \$106.67 per mile
VC_{tiller} = [2(11) + 1.20]/0.04 = \$580 per mile

$FC_{excavator}$ = -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 per year

FC_{tiller} = -1200(A/P,10%,5)
= -1200(0.26380)
= \$-316.56 per year

Equate the AW relations and let x = breakeven miles per year

$$-21{,}748 – 106.67x = -316.56 – 580x$$
$$x = 45.3 \text{ miles per year}$$

13.20 $$-(920 + 360)(A/P,10\%,3) – 3.10x = -3850(A/P,10\%,5) – 1.28x$$
$$-1280(0.40211) – 3.10x = -3850(0.26380) – 1.28x$$
$$1.82x = 500.93$$
$$x = 275 \text{ hours per year}$$

13.21 (a) Solve the relation $AW_{buy} = AW_{make}$ for Q = number of units per year.

$$-25Q = -150{,}000(A/P,12\%,5) + 15{,}000(A/F,12\%,5) – 35{,}000 – 5Q$$
$$-20Q = -150{,}000(0.27741) + 15{,}000(0.15741) – 35{,}000$$
$$Q = -74{,}250/-20$$
$$= 3713 \text{ units per year}$$

(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.

$$-6500 -6500(1.20)(P/F,10\%,4) -6500(1.20)^2(P/F,10\%,8) = -P_S - P_S(1.40)(P/F,10\%,6)$$
$$-6500 – 6500(1.20)(0.6830) -6500(1.20)^2(0.4665) = -P_S - P_S(1.40)(0.5645)$$

$$1.79P_S = 16,193.84$$
$$P_S = \$9045$$

13.23 (a) Develop PW = 0 relation and solve for first cost P.

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

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							

GOAL SEEK solutions

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.

$$-800(A/P,10\%,8) - 300x = -1600(A/P,10\%,10) - 3x - 12(8200)(A/P,10\%,10)$$
$$-800(0.18744) - 300x = -1600(0.16275) - 3x - 98{,}400(0.16275)$$
$$-149.95 - 300x = -16275 - 3x$$
$$297x = 16125.05$$
$$x = 54.3 \text{ days per year}$$

(b) If the lagoon is pumped 52 times per year and P = cost of pipeline, the breakeven equation becomes:

$$-800(0.18744) - 300(52) = -1600(0.16275) - 3(52) + P(0.16275)$$
$$-15{,}750 = -416.4 + 0.16275P$$
$$P = \$-94{,}216$$

13.27 (a) Solve the relation $AW_N = AW_A$ for H = number of hours per year.

$$-4000(A/P,10\%,3) -1000(H/2000) -1H = -10{,}300(A/P,10\%,6) -2200(H/8000) -0.9H$$
$$(-.5-1+0.275+0.9)H = -10{,}300(0.22961) + 4000(0.40211)$$
$$-0.325H = -756.5$$
$$H = 2328 \text{ hours per year}$$

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 $AW_{lease} - AW_{buy} = 0$ for N = number of months Monthly i = 1.25%.

$$-800 + 8500(A/P,1.25\%,N) + 75 = 0$$

For N = 12: -800 + 8500(0.09026) + 75 = $42.21
For N = 13: -800 + 8500(0.08382) + 75 = $-12.53

N = 12.8 months (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.

13.29 AW_{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

AW_{Leaf} = -500(A/P,0.75%,60) - 349
= -500(0.02076) - 349
= $-359.38

$AW_{RA\ removal}$ = 527.70 - 359.38
= $168.32 per month

13.30 (a) n_p = 28,000/(5000-1500)
= 8 months

(b) 0 = -28,000 + (5000 – 1500)(P/A,3%,n_p)

Try 8 months: -28,000 + 3500(7.0197) = $-3431

Try 10 months: -28,000 + 3500(8.5302) = $1856

n = 9.3 months (interpolation)

(c) 0%: = NPER(0%,3500,-28000) displays 8.0 months
3%: = NPER(3%,3500,-28000) displays 9.3 months

13.31 (a) 0 = -28,000 + 2900(P/A,8%,n) + 1500(P/F,8%,n)

n = 15: 0 = -28,000 + 2900(8.5595) + 1500(0.3152) = $2705
n = 20: 0 = -28,000 + 2900(9.8181) + 1500(0.2145) = $-794

n_p = 18.7 years (interpolation or NPER function)

(b) Since n is greater than the useful period of 12 years, the asset should not be purchased

13.32 (a) Set PW = 0 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)

i = 0%, n = 5: PW = -3,150,000 + 500,000(5) + 400,000
= $-250,000

i = 0%, n = 6: PW = -3,150,000 + 500,000(6) + 400,000
= $250,000

n_p = 5.5 years (interpolation)

i = 8%, n = 8: PW = -3,150,000 + 500,000(5.7466) + 400,000(0.5403)
= $-60,580

i = 8%, n = 9: PW = -3,150,000 + 500,000(6.2469) + 400,000(0.5002)
= $173,530

n_p = 8.2 years (interpolation)

(b) *i = 15%, n = 19:* PW = -3,150,000 + 500,000(6.1982) + 400,000(0.0703)
= $-22,780

i = 15%, n = 20: PW = -3,150,000 + 500,000(6.2593) + 400,000(0.0611)
= $4090

n_p = 19.8 years (interpolation)

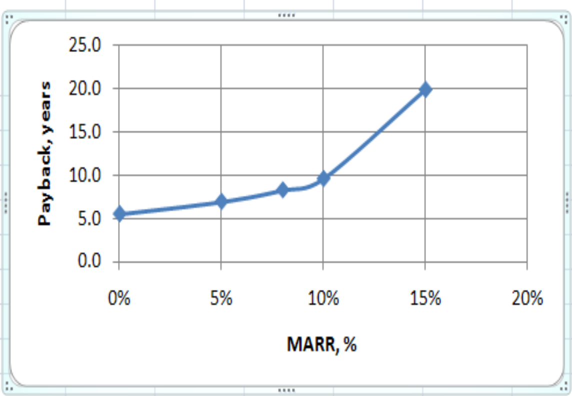
i = 16%, n = 60: PW = -3,150,000 + 500,000(6.2492) + 400,000(0.0001)
= $-25,360

n_p > 60 years (beyond tabulated n values)

(Note: As n → ∞, 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.)

MARR, %	Payback using NPER function, years
0%	5.5
5%	6.9
8%	8.3
10%	9.6
15%	19.8
16%	#NUM!



13.33 (a) Set PW = 0 and solve for n_p

$$0 = -1050 + 600(P/F,10\%,n_p) + 175(P/A,10\%,n_p) + 45(P/G,10\%,n_p)$$

For n = 3: PW = \$-59
For n = 4: PW = \$111.50

n_p = 3.3 years (interpolation)

(b) The equipment should be purchased, since 3.3 < 7 years

13.34 $-250{,}000 - 500n + 250{,}000(1 + 0.02)^n = 100{,}000$

Try n = 18: 98,062 < 100,000
Try n = 19: 104,703 > 100,000

n_p is 18.3 months or 1.6 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*

$$PW = -75{,}000 - 10{,}500(P/F,i^*,1) + \ldots + 105{,}000(P/F,i^*,5) = 0$$

i* = 13.96% (IRR function)

(c) Calculate PW at 7% by year to determine when PW turns positive. Start with n = 3 years.

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

n = 4: PW = -70,201 +28,000(P/F,7%,4)
= \$-48,840

n = 5: PW = -48,840 +105,000(P/F,7%,5)
= \$26,025

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
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	=SUM(B3:B7)		
9	(b) ROR	13.96%			7% payback occurs during 5th year.
10			=IRR(B2:B7)		
11					

13.36 (a) Calculate capital return (CR) at a 5% return. S = 0.

n = 3: CR = -45,000(A/P,5%,3)
= -45,000(0.36721)
= $-16,524 per year

n = 5: CR = -45,000(A/P,5%,5)
= $-10,394 per year

n = 8: CR = -45,000(A/P,5%,8)
= $-6962 per year

n = 10: CR = -45,000(A/P,5%,10)
= $-5828 per year

For spreadsheet solution, progressively enter = -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.

PW = 5000(P/A,5%,10)
= -5000(7.7217)
= $38,609

13.37 Monthly i = 9/12 = 0.75%. Solve PW relations for n_p

(a) Purchase: PW = -30,000 + 3500(P/A,0.75%,n_p)
(P/A,0.75%,n_p) = 8.5714

n_p = 8.9 months (interpolation)

For spreadsheet solution, enter = NPER(0.75%,3500,-30000) to display 8.9

(b) Lease: 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.

$PW = -10,000 + 2000(P/A,0.75\%,n_p)$

$(P/A,0.75\%,n) = 5.0$

$n = 5.1$ months (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: Sum = -15,000-2(2000)+2(1000)+2(6000) = $-5000

n = 7: 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.

n = 7: PW = -15,000 -2000(P/A,1.5%,2) +1000(P/A,1.5%,2)(P/F,1.5%,2)
+6000(P/A,1.5%,3)(P/F,1.5%,4)
= $-550

n = 8: PW = -15,000 -2000(P/A,1.5%,2) +1000(P/A,1.5%,2)(P/F,1.5%,2)
+6000(P/A,1.5%,3)(P/F,1.5%,4) +9000(P/F,1.5%,8)
= $7439

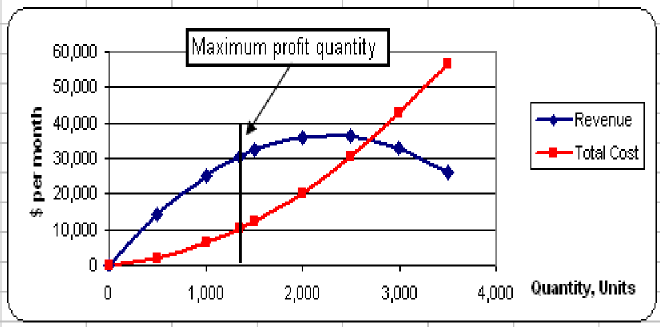
Payback is $n_p = 7.1$ months (interpolation)

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

	A	B	C	D
1		Q^2	Q	constant
2	R =	-0.007	32	
3	TC =	0.004	2.2	8
4				
5	Quantity	Revenue	Total Cost	Profit
6	0	0	8	-8
7	500	14,250	2,108	12142
8	1,000	25,000	6,208	18792
9	1,355	30,508	10,333	20175
10	1,500	32,250	12,308	19942
11	2,000	36,000	20,408	15592
12	2,500	36,250	30,508	5742
13	3,000	33,000	42,608	-9608
14	3,500	26,250	56,708	-30458
15				



(b) $\text{Profit} = R - TC = (-.007-.004)\,Q^2 + (32-2.2)Q - 8$

$= -.011Q^2 + 29.8Q - 8$

$Q_p = -b/2a = -29.8/2(-.011)$

$= 1355$ 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 = Revenue – 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 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
1	Year	Costs	Revenues	Net cash flow
2	0	-150000		-150000
3	1	-42000	50000	8000
4	2	-42000	72141	30141
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

GOAL SEEK result

All cells are =C$4

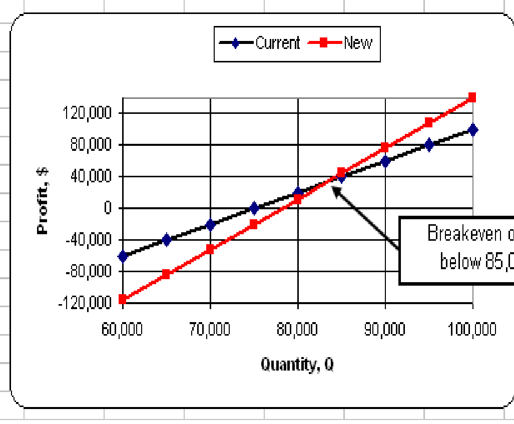
=C$4+20000

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

	A	B	C
1	System	Q	Constant
2	Current	4.0	300,000
3	New	6.4	500,000
4			
5	Q	Current	New
6	60,000	-60,000	-116,000
7	65,000	-40,000	-84,000
8	70,000	-20,000	-52,000
9	75,000	0	-20,000
10	80,000	20,000	12,000
11	85,000	40,000	44,000
12	90,000	60,000	76,000
13	95,000	80,000	108,000
14	100,000	100,000	140,000



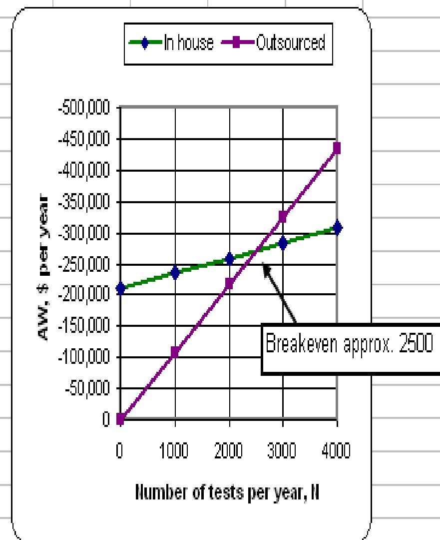
13.45 Solve the relation $AW_I = AW_O$ for N = number of tests per year

$$-125,000(A/P,5\%,8) – 190,000 -25N = -100N – 25N(F/A,5\%,3)(A/F,5\%,8)$$
$$[75 + 25(3.1525)(0.10472)]N = 125,000(0.15472) + 190,000$$
$$83.25N = 209,340$$
$$N = 2514 \text{ tests per year}$$

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.

	A	B	C	D	E	F	G	H
1	Year	In-house	Outsourced	Tests,	AW computation		AW values	
2	0	-125,000		N	In-house	Outsourced	In-house	Outsourced
3	1	-190,000	0	0	-209,340	0	-209,340	0
4	2	-190,000	0	1000			-234,340	-108,253
5	3	-190,000	0	2000			-259,340	-216,507
6	4	-190,000	0	3000			-284,340	-324,760
7	5	-190,000	0	4000			-309,340	-433,014
8	6	-190,000	0					
9	7	-190,000	0					
10	8	-190,000	0					

Used to calculate AW's for N values in column D; results are in G and H



13.47 It will raise the breakeven point. Outsourcing will cost \$75, increasing to \$93.75 in years 6- 8. Resolve for N.

$$-125{,}000(A/P,5\%,8) - 190{,}000 - 25N = -75N - 18.75N(F/A,5\%,3)(A/F,5\%,8)$$
$$[50 + 18.75(3.1525)(0.10472)]N = 125{,}000(0.15472) + 190{,}000$$
$$56.19N = 209{,}340$$
$$N = 3726 \text{ tests per year}$$

13.48 It will decrease the breakeven point. Resolve for N.

$$-125{,}000(A/P,5\%,8) - 115{,}000 - 20N = -100N - 25N(F/A,5\%,3)(A/F,5\%,8)$$
$$[80 + 25(3.1525)(0.10472)]N = 125{,}000(0.15472) + 115{,}000$$
$$88.25N = 134{,}340$$
$$N = 1522 \text{ tests per year}$$

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)

13.53 $-100N = -250{,}000(A/P,15\%,4) – 80{,}000 – 40N$
$60N = 250{,}000(0.35027) + 80{,}000$
$N = 2793$

Since slope of Make is lower, Make would be cheaper above breakeven point

Answer is (b)

13.54 $-10{,}000 - 50x = -21{,}500 - 10x$
$x = 287.5$

Answer is (a)

13.55 Both the fixed and variable costs are lower for Y; Y is better

Answer is (a)

13.56 $-100{,}000(A/P,6\%,10) -10{,}000 = -30{,}000(A/P,6\%,5) – x$
$-100{,}000(0.13587) -10{,}000 = -30{,}000(0.23740) – x$
$x = 16{,}465$

Answer is (c)

13.57 $-50{,}000(A/P,8\%,5) – 100x = -400x$
$-50{,}000(0.25046) – 100x = -400x$
$x = 41.7$ days

Answer is (b)

13.58 Answer is (b)

13.59 Set AW relations equal and solve for x, the cost of the enamel coating

$-5000(A/P,8\%,5) – 1000(P/F,8\%,3)(A/P,8\%,5) = x(A/P,8\%,2)$
$-5000(0.25046) – 1000(0.7938)(0.25046) = x(0.56077)$
$x= \$2588$

Answer is (c)

13.60 $50{,}000 + 2400n_p = 25{,}000(F/P,20\%,n_p)$

Solve for n_p

$n_p = 4.99$ years

Answer is (b)

13.61 $-16{,}000 - 40(1000) = -FC - (125/5)(1000)$

$FC = \$31{,}000$

Answer is (d)

13.62 Breakeven: $-500{,}000 = (250 - 200)x$

$x = 10{,}000$ units

20% above = 12,000 units

Answer is (b)

13.63 $VC_B = 40(4)/8$

$= \$20$ per mile

Answer is (c)

13.64 $-28{,}000(A/P,10\%,n) + 5000 - 1500 = 0$

$(A/P,10\%,n) = 3500/28{,}000$

$= 0.125$

$n = 16.9$ 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 hp * 0.75 kw/hp * 0.12 $/kwh * 24 hr/day * 30.5 days/mo ÷ 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) $$1107/30.5 = (40)(0.75)(x)(24)/0.90$$
$$x = 4.5 \text{ cents per kwh}$$

(c) $$1{,}849/30.5 = (5)(0.75)(x)(24)/0.90 + (40)(0.75)(x)(24)/0.90$$
$$x = 6.7 \text{ cents per kwh}$$

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 $0.10 = 0.04 + f + 0.04f$
$1.04f = 0.06$
$f = 0.0577$ or 5.77% per year

14.4 $i_f = 0.20 + 0.05 + (0.20)(0.05)$
$= 0.26$ or 26%

14.5 i_f per month $= 0.30/12 + 0.015 + (0.30/12)(0.015)$
$= 0.040375$ or 4.0375% per month

Nominal i_f per year $= 12(4.0375)$
$= 48.45\%$ per year

14.6 $0.35 = 0.25 + f + 0.25f$
$1.25f = 0.10$
$f = 0.08$ or 8% per year

14.7 $i_f = 0.04 + 0.01 + (0.04)(0.01)$
$= 0.0504$ or 5.04% per quarter

14.8 i_f per month $= 18/12 = 1.5\%$

Use inflation-adjusted interest rate equation to solve for i.

$0.015 = i + 0.005 + (i)(0.005)$
$1.005i = 0.01$
$i = 0.00995$ or 0.995% 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

$2C_1 = C_1(1 + 0.07)^n$
$(1 + 0.07)^n = 2.000$
$n \log 1.07 = \log 2.000$
$n = 10.2$ years

14.13 $0.28 = i + 0.06 + i(0.06)$
$1.06i = 0.22$
$i = 0.2075$ or 20.75%

14.14 (a) Inflation rate, f = [(2472.4 – 113.6)/113.6]*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,

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) $0.096 = 0.05 + f + 0.05f$
$1.05f = 0.046$
$f = 4.38\%$ per year

14.23 P_g = 350{1- [(1+0.03/1 + 0)^{31}]/0 - 0.03}
= 350(50)
= $17,500

Savings = 17,500 – 350(31)
= $6650
or
Savings = 350(F/A,3%,31) – 350(31)
= 350(50.0027) – 10,850
= $6651

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.

14.25 i_f = 0.10 + 0.04 + (0.10)(0.04)
= 14.4%

PW = 50,000(P/F,14.4%,2)
= 50,000[1/(1.144)^2]
= $38,205

14.26 i_f = 0.10 + 0.04 + (0.10)(0.04)
= 14.4%

PW = 125,000(P/F,14.4%,3)
= 125,000(0.66792)
= $83,490

14.27 i_f = 0.12 + 0.03 + (0.12)(0.03)
= 15.36%

PW = 75,000(P/F,15.36%,4)
= 75,000[(1/(1.1536)^4]
= 75,000(0.56465)
= $42,349

14.28 Convert all cash flows into CV dollars and then use i.

PW = 3000(P/F,8%,1) + [6000/(1 + 0.06)^2](P/F,8%,2)
+ [8000/(1 + 0.06)^3](P/F,8%,3) + 4000(P/F,8%,4)
+ 5000(P/F,8%,5)
= 3000(0.9259) + 5340(0.8573) + 6717(0.7938)
+ 4000(0.7350) + 5000(0.6806)
= $19,031

14.29 The $1.9 million are then-current dollars. Use i_f to find PW

$i_f = 0.15 + 0.03 + (0.15)(0.03) = 18.45\%$

PW = 1,900,000(P/F,18.45%,3)
= 1,900,000[(1/(1 + 0.1845)^3]
= $1,143,269

14.30 (a) Use i = 10%

F = 68,000(F/P,10%,2)
= 68,000(1.21)
= $82,280

Purchase later for $81,000

(b) Use i_f = 0.10 + 0.05 (0.10)(0.05)

F = 68,000(F/P,15.5%,2)
= 68,000(1 + 0.155)^2
= 68,000(1.334)
= $90,712

Purchase later for $81,000

14.31 Use the real i for salesman A and inflated i_f for Salesman B.

$i_f = 0.20 + 0.04 + (0.20)(0.04) = 24.8\%$

PW_A = -140,000 – 25,000(P/A,20%,10)
= -140,000 – 25,000(4.1925)
= $-244,812

PW_B = -155,000 – 40,000(P/A,24.8%,10)
= -155,000 – 40,000(3.5923)
= $-298,692

Recommend purchase from salesman A

14.32 $i_f = 0.12 + 0.04 + (0.12)(0.04)$
= 16.48%

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

PW_{AG} = \$1,700,000

Select IWS

14.33 i_f per month = 0.01 + 0.004 + (0.01)(0.004) = 1.4%

PW_S = 2,300,000(P/F,1.4%,120)
= 2,300,000[(1/(1 + 0.014)^{120}]
= \$433,684

PW_L = 2,500,000(P/F,1.4%,120)
= 2,500,000[(1/(1 + 0.014)^{120}]
= \$471,395

14.34 Find present worth of all three plans.

Method 1: PW_1 = \$480,000

Method 2: i_f = 0.10 + 0.06 + (0.10)(0.06) = 16.6%

PW_2 = 1,100,000(P/F,16.6%,5)
= 1,100,000(0.46399)
= \$510,389

Method 3: PW_3 = 850,000(F/P,6%,5)(P/F,16.6%,5)
= \$850,000(1.3382)(0.46399)
= \$527,775

CCS should select payment method 3

14.35 i_f = 0.10 + 0.06 + (0.10)(0.06)
= 16.6% per year

F = 10,000(F/P,16.6%,10)
= 10,000(1 + 0.166)^{10}
= \$46,450

14.36 Find F in future dollars using f = -3.0%

F = 50,000(1 – 0.03)^5
= 50,000(0.85873)
= \$42,937

14.37 Purchasing power = 100,000(F/P,10%,15)/(1 - 0.01)^{15}
= 100,000(4.1772)/0.86006
= \$485,687

14.38 Buying power = $60{,}000(F/A,10\%,5)/(1 + 0.04)^5$
$= 60{,}000(6.1051)/1.21665$
$= \$301{,}078$

14.39 $8{,}000{,}000(1 + f)^4 = 7{,}000{,}000(F/P,7\%,4)$
$8{,}000{,}000(1 + f)^4 = 7{,}000{,}000(1.3108)$
$8{,}000{,}000(1 + f)^4 = 9{,}175{,}600$
$(1 + f)^4 = 1.14695$
$4[\log (1+f)] = \log 1.14695$
$4[\log (1+f)] = 0.05954$
$\log(1 + f) = 0.01489$
$1 + f = 10^{0.01489}$
$1 + f = 1.03487$
$f = 3.487\%$ per year

14.40 (a) $25{,}000 = 10{,}000(F/P,i,5)$
$(F/P,i,5) = 2.5000$

$i = 20.1\%$ (solve F/P equation, interpolation or RATE function)

(b) $0.201 = i + 0.04 + i(0.04)$
$1.04i = 0.161$
$i = 15.48\%$

(c) Buying power = $25{,}000/(1 + 0.04)^5$
$= \$20{,}548$

14.41 Cost = $(3)32{,}350(1 + 0.035)^2$
$= \$103{,}962$

14.42 (a) $1{,}400{,}000 = 653{,}000(1 + f)^{13}$
$(1 + f)^{13} = 2.14395$
$f = 6.04\%$

(b) The market rate is f + 5%.

$i_f = 0.03 + 0.05$
$F = 1{,}400{,}000(1.08)^{11}$
$= \$3{,}264{,}295$

14.43 $i_f = 0.15 + 0.028 + (0.15)(0.028)$
$= 18.22\%$

$F = 2{,}400{,}000(F/P,18.22\%,3)$
$= 2{,}400{,}000(1 + 0.1822)^3$
$= \$3{,}965{,}374$

14.44 (a) Cost, year 20: machine A = 10,000(1.10)(1.10)(1.02)(1.02)…(1.02)
= $31,617.58

Cost, year 20: machine B = 10,000(1.02)(1.02)(1.10)(1.10)…(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.

$$F = 72,000(1 + 0.05)^3$$
$$= 72,000(1.1576)$$
$$= \$83,347$$

$$A = 83,347(A/F,12\%,3)$$
$$= 83,347(0.29635)$$
$$= \$24,700 \text{ per year}$$

14.48 $i_f = 0.22 + 0.05 + (0.22)(0.05)$
$= 28.1\%$

$$A = 500,000(A/P,28.1\%,5)$$
$$= 500,000(0.39572)$$
$$= \$197,860$$

14.49 $i_f = 0.15 + 0.05 + (0.15)(0.05)$
$= 20.75\%$

$$AW_X = -65,000(A/P,20.75\%,5) – 40,000$$
$$= -65,000(0.33991) – 40,000$$
$$= \$-62,094$$

$$AW_Y = -90,000(A/P,20.75\%,5) – 34,000 + 10,000(A/F,20.75\%,5)$$
$$= -90,000(0.33991) – 34,000 + 10,000(0.13241)$$
$$= \$-63,268$$

Therefore, select process X

14.50 $i_f = 0.12 + 0.03 + (0.12)(0.03)$
$= 15.36\%$

$$A = -3,700,000(A/P,15.36\%,5)$$
$$= -3,700,000(0.30086)$$
$$= \$-1,113,182 \text{ per year}$$

14.51 $i_f = 0.10 + 0.04 + (0.10)(0.04)$
$= 14.4\%$ per year

$$A = -40,000(A/P,14.4\%,3) - 24,000 + 6000(A/F,14.4\%,3)$$
$$= -40,000(0.43363) - 24,000 + 6000(0.28963)$$
$$= \$-39,607 \text{ per year}$$

14.52 $i_f = 0.09 + 0.03 + (0.09)(0.03)$
$= 12.27\%$ per year

$A = -180{,}000(A/P,12.27\%,5) - 70{,}000(P/F,12.27\%,3)(A/P,12.27\%,5)$
$= -180{,}000(0.27927) - 70{,}000(0.70666)(0.27927)$
$= \$-64{,}083$ per year

14.53 $i_f = 0.20 + 0.05 + (0.20)(0.05)$
$= 26\%$ per year

(a) $CR = A = 2{,}500{,}000(A/P,26\%,5)$
$= 2{,}500{,}000(0.37950)$
$= \$948{,}750$ per year

(b) Now the $2.5 million is a future value

$CR = A = 2{,}500{,}000(A/F,26\%,5)$
$= 2{,}500{,}000(0.11950)$
$= \$298{,}750$

(c) Calculate CR at i = 20% for F = $2.5 million

$CR = A = 2{,}500{,}000(A/F,20\%,5)$
$= 2{,}500{,}000(0.13438)$
$= \$335{,}950$

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 Cost $= 40{,}000/(1 + 0.06)^{10}$
$= \$22{,}336$

Answer is (b)

14.60 $F = 1000(F/P,5\%,25)$
$= 1000(3.3864)$
$= \$3386$

Answer is (b)

14.61 $i_f = 0.06 + 0.04 + (0.06)(0.04)$
$= 10.24\%$

$F = 1000(1 + 0.1024)^{10}$
$= \$2650.89$

Answer is (c)

14.62 $i_f = 0.04 + 0.03 + (0.04)(0.03)$
$= 7.12\%$

$P = 50,000[1/(1 + 0.0712)^{6}]$
$= \$33,094$

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
20	#4. Sell at buying power - dividend future value		$55,416		$47,292

5. 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

   Bonds: P = 50,000(P/F,11.28%,12) + 2500(P/A,11.28%,12)
   = 50,000(0.27733) + 2500(6.40666)
   = $29,883

   (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.

Solutions to end-of-chapter problems

Engineering Economy, 7th edition
Leland Blank and Anthony Tarquin

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 ±20% of the actual cost.

15.8 Cost = 120(58.19) = \$6983

15.9 Cost = 600(4700) = \$2,820,000

15.10 Estimated cost = 496(6000)
= \$2,976,000

15.11 Cost = 1,350,000(1.70/0.93)
= \$2,467,742

15.12 Cost/volume = $185/[(1 ft^2)(10 ft)] = \$18.50\ ft^3$

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

Predicted index value in 2009 = 7446(F/P,3.13%,4)
$= 7446(1+0.0313)^4$
= 8423

(b) Difference = 8570 – 8423
= 147 (underestimate)

15.21 At 1% per month, annual increase = $(1 + 0.01)^{12}$ -1 = 12.68%

Index value = 100(1.1268) = 112.68

15.22 Let f = inflation rate

(a) f = (8837.38 – 8563.35)/8563.35 = 0.032

(b) CCI = $8837.38(1 + f)^3$
$= 8837.38(1.032)^3$
= 9713.21

15.23 Cost = 194(1461.3/789.6)
= $359

15.24 Value in NY = 54.3 million(12,381.40/4874.06) = $137.94 million

15.25 CCI in 1967 = 8837.37/8.2272 = 1074.16

15.26 96.55 = (Cost in 1913)(2708.51/100)

Cost in 1913 = $3.56 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

Year = 2010 - 23
= 1987

(b) Index value = $1461.3/(1.0268)^{23}$
= 795.4

15.28 The labor cost index probably increased by more than 2%.

15.29 (a) Cost = $28,000[(125/200)^{0.69}$

$= \$20,245$

(b) $\text{Cost} = 4100[(1700/900)^{0.67}$
$= \$6278$

15.30 $C_2 = 13,000(500/4)^{0.37}$
$= \$\ 77,589$

15.31 $C_2 = 58,890(2/0.75)^{0.58} = \$104,017$

15.32 Use the six-tenths model; exponent = 0.60

$20,000 = C_1(300/100)^{0.60} = 1.93318C_1$
$C_1 = \$10,346$

15.33 $1.52C_1 = C_1(68/30)^x$
$\log 1.52 = x \log 2.267$
$x = 0.51$

15.34 Area of 12" pipe $= \pi(1)^2/4$
$= 0.785\ ft^2$

Area of 24" pipe $= \pi(2)^2/4$
$= 3.142\ ft^2$

$27.23 = 12.54(3.142/0.785)^x$
$2.17 = 4.00^x$
$\log 2.17 = x \log 4$
$0.336 = 0.602x$
$x = 0.56$

15.35 Use Equation [15.4] and Table 15-3

$\text{Cost} = 1.2 \text{ million}[450,000/100,000)^{0.67}](575.8/394.3)$
$= \$4.8 \text{ million}$

15.36 $\text{Cost} = 3750(2)^{0.89}\ (1620.6/1104.2)$
$= \$10,199$

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

$376,900 = C_1(1449.3/1061.9)(4)^{0.61}$
$C_0 = \$118,548$

15.38 $C_2 = 0.942C_1 = C_1(2)^x$

$\log 0.942 = x \log 2$

$x = -0.0862$

15.39 $C_T = 2.25(1{,}800{,}000) = \$4{,}050{,}000$

15.40 $1{,}320{,}000 = h(225{,}000)$

$h = 5.87$

15.41 $C_T = (1 + 1.32 + 0.45)(870{,}000)$

$= \$2{,}409{,}900$

15.42 First find direct cost; then multiply by indirect cost factor:

$h = 1 + 1.28 + 0.23 = 2.51$

$C_T = [243{,}000(2.51)](1.84)$

$= \$1{,}122{,}271$

15.43 $2{,}300{,}000 = (1 + 1.35 + 0.41)C_E$

$C_E = \$833{,}333$

15.44 $C_T = [400{,}000(1 + 3.1)][1 + 0.38]$

$= \$2{,}263{,}200$

15.45 (a) $h = 1 + 0.30 + 0.30 = 1.60$

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) $C_T = 250{,}000[1.60](1.40)$

$= \$560{,}000$

15.46 Total direct labor hours = 2000 + 8000 + 5000

= 15,000 hours

Indirect cost rate/1000 hr = 36,000/15,000

= $2.40

Allocation to Dept A = 2000(2.40)
= $4800

Allocation to Dept B = 8000(2.40)
= $19,200

Allocation to Dept C = 5000(2.40)
= $12,000

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

Percent distributed = (235,675 + 310,000 + 390,165)/1.2 million × 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

AW_{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

AW_{buy} = -3,900,000 – 300,000(A/G,12%,6)
= -3,900,000 – 300,000(2.1720)
= $-4,551,600

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

Allocation/Trip = 380,000/387
= $981.91

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
		$380,000

(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	4	80,000
	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 × 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)

15.63 $3{,}000{,}000 = 550{,}000(100{,}000/6000)^x$

$5.4545 = (16.67)^x$

$\log 5.4545 = x\log(16.67)$

$x = 0.60$

Answer is (d)

15.64 $C_T = 2.96(390{,}000) = \$1{,}154{,}400$

Answer is (c)

15.65 $C_T = (1 + 1.82 + 0.31)(650{,}000)$

$= \$2{,}034{,}500$

Answer is (a)

15.66 Answer is (d)

15.67 Allocation = (900 + 1300)(2000) = $4.4 million

Percent allocated = 4.4/8.0 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/DLH

Premium: rate = $\frac{\$3.33 \text{ million}}{125{,}000 \text{ hrs}}$ = \$26.64/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

	Standard		Premium	
Driver	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	670,000
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	1,680.000
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	575,000
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/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

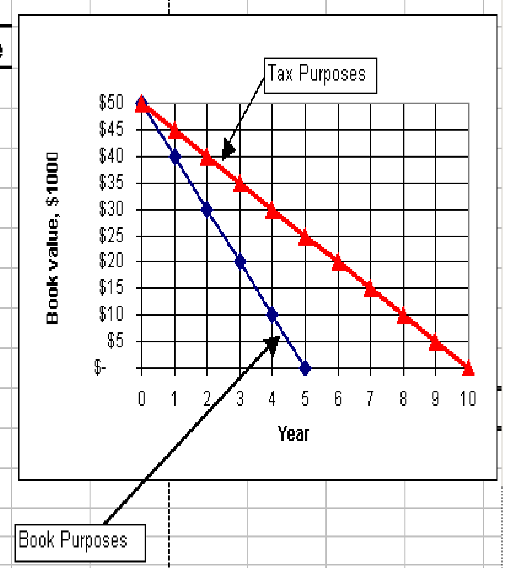
S = 0 (MACRS does not use an estimated salvage value)

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.

	A	B	C	D	E
1		Book purposes		Tax purposes	
2	Year	Depreciation	Book value	Depreciation	Book value
3	0		$ 50,000		$ 50,000
4	1	$ 10,000	$ 40,000	$ 5,000	$ 45,000
5	2	$ 10,000	$ 30,000	$ 5,000	$ 40,000
6	3	$ 10,000	$ 20,000	$ 5,000	$ 35,000
7	4	$ 10,000	$ 10,000	$ 5,000	$ 30,000
8	5	$ 10,000	$ -	$ 5,000	$ 25,000
9	6			$ 5,000	$ 20,000
10	7			$ 5,000	$ 15,000
11	8			$ 5,000	$ 10,000
12	9			$ 5,000	$ 5,000
13	10			$ 5,000	$ -
14					
15					



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

$D_t = 30{,}000/2 = \$15{,}000$ 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

$D_t = 50{,}000/4 = \$12{,}500$ per year

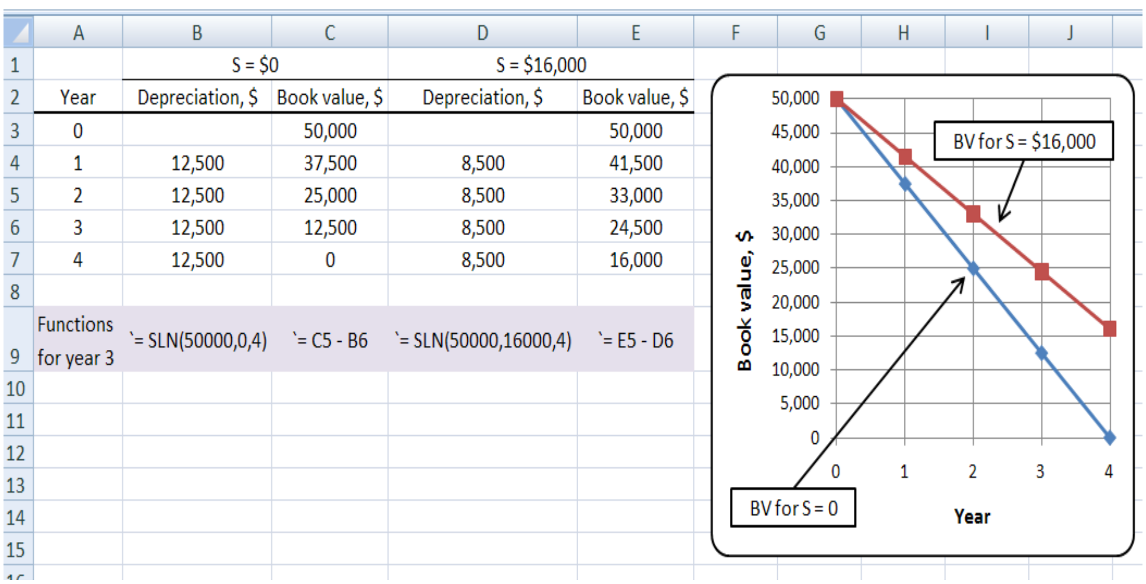
Year, t	D_t	Accumulated depreciation	BV_t
0	---	---	$50,000
1	$12,500	$12,500	37,500
2	12,500	25,000	25,000
3	12,500	37,500	12,500
4	12,500	50,000	0

(b) S = $16,000; d = 0.25; B - S = $34,000

D_t = (50,000 - 16,000) /4 = $8500 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.



	A	B	C	D	E
1		S = $0		S = $16,000	
2	Year	Depreciation, $	Book value, $	Depreciation, $	Book value, $
3	0		50,000		50,000
4	1	12,500	37,500	8,500	41,500
5	2	12,500	25,000	8,500	33,000
6	3	12,500	12,500	8,500	24,500
7	4	12,500	0	8,500	16,000
8					
9	Functions for year 3	`= SLN(50000,0,4)	`= C5 - B6	`= SLN(50000,16000,4)	`= E5 - D6

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	=SLN(2000000,0.2*2000000,5) - SLN(2000000,0.2*2000000,8)						
4	(b) BV_5				$600,000			
5	Function	=5*SLN(2000000,0.2*2000000,5) - 5*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) 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

$BV_{12} = B(1\text{-}d)^{12} = 180{,}000(1\text{-}0.167)^{12}$
= \$20,092

150% DB: d = 1.5/12 = 0.125

$BV_{12} = 180{,}000(1\text{-}0.125)^{12}$
= \$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 stops 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
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
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	

= DDB(100000,12500,7,A10,2)

= SLN(100000,10000,10)

= DDB(100000,0,7,A10,2)

= SLN(100000,12500,10)

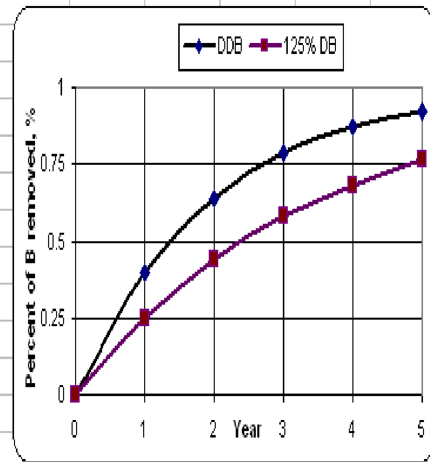
16.24 Select any first cost value to use for B. The spreadsheet below uses \$10,000.

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.

	DDB				125% DB			
Year	BV	Depr	Acc Depr	% B removed	BV	Depr	Acc Depr	% B removed
0	10,000			0	10,000			0
1	6,000	4,000	4,000	0.40	7,500	2,500	2,500	0.25
2	3,600	2,400	6,400	0.64	5,625	1,875	4,375	0.44
3	2,160	1,440	7,840	0.78	4,219	1,406	5,781	0.58
4	1,296	864	8,704	0.87	3,164	1,055	6,836	0.68
5	778	518	9,222	0.92	2,373	791	7,627	0.76

= 0.4*B7 = D8/B$3 = (1.25/5)*F7



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_t 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

MACRS: BV_4 = 80,000 – 80,000(0.20 + 0.32 + 0.192 + 0.1152)
= 80,000 - 66,176
= $13,824

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

DDB: d = 2/5 = 0.40

$BV_3 = 300,000(1 – 0.4)^3$
= $64,800

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 = rate(1,200,000) and $BV_t = BV_{t-1} - D_t$

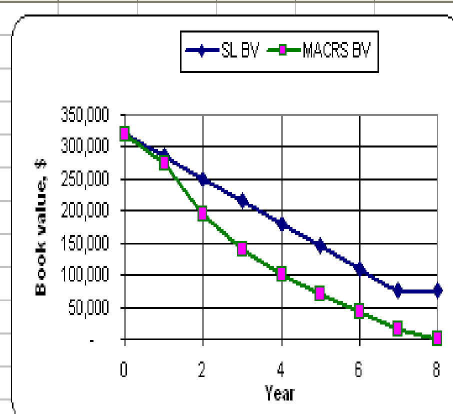
	A	B	C	D	E	F
1		MACRS via VDB function		MACRS via tabulated rates		
2	Year	Depreciation	Book value	Rate	Depreciation	Book value
3	0		1,200,000			1,200,000
4	1	171,429	1,028,571	0.1429	171,480	1,028,520
5	2	293,878	734,694	0.2449	293,880	734,640
6	3	209,913	524,781	0.1749	209,880	524,760
7	4	149,938	374,844	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 = 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.

	A	B	C	D	E	F
1		Straight line		MACRS		
2	Year	Depr	SL BV	Rate	Depr	MACRS BV
3	0		320,000			320,000
4	1	35,000	285,000	0.1429	45,728	274,272
5	2	35,000	250,000	0.2449	78,368	195,904
6	3	35,000	215,000	0.1749	55,968	139,936
7	4	35,000	180,000	0.1249	39,968	99,968
8	5	35,000	145,000	0.0893	28,576	71,392
9	6	35,000	110,000	0.0892	28,544	42,848
10	7	35,000	75,000	0.0893	28,576	14,272
11	8	0	75,000	0.0446	14,272	0
12	Total	245,000		1.0000	320,000	



(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: $d = 2/15 = 0.13333$

$D_3 = 0.13333(800{,}000)(1\text{-}0.13333)^2 = \$80{,}117$

$BV_3 = 800{,}000(1\text{-}0.1333)^3 = \$520{,}776$

(c) ADS SL: $d = 1/15 = 0.06666$ years 2 through 15; ½ that for years 1 and 16.

$D_3 = 0.06666(800000\text{-}150{,}000) = \$43{,}329$

$BV_3 = 800{,}000 – 2.5(43{,}329) = \$691{,}678$

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

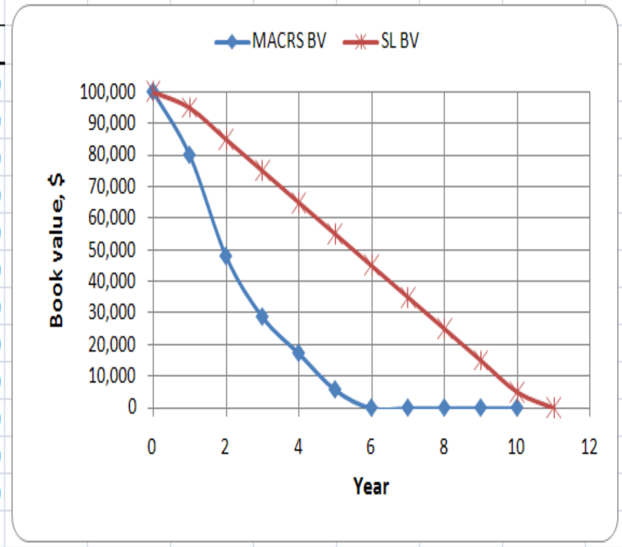
SL: n = 10, d = 0.05 in years 1 and 11 and d = 0.1 in all others

Hand solution

	MACRS			SL		
Year	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

	5-year MACRS		10-year Straight line	
Year	Depreciation	MACRS BV	Depreciation	SL BV
0		100,000		100,000
1	20,000	80,000	5,000	95,000
2	32,000	48,000	10,000	85,000
3	19,200	28,800	10,000	75,000
4	11,520	17,280	10,000	65,000
5	11,520	5,760	10,000	55,000
6	5,760	0	10,000	45,000
7		0	10,000	35,000
8		0	10,000	25,000
9		0	10,000	15,000
10		0	10,000	5,000
11			5,000	0



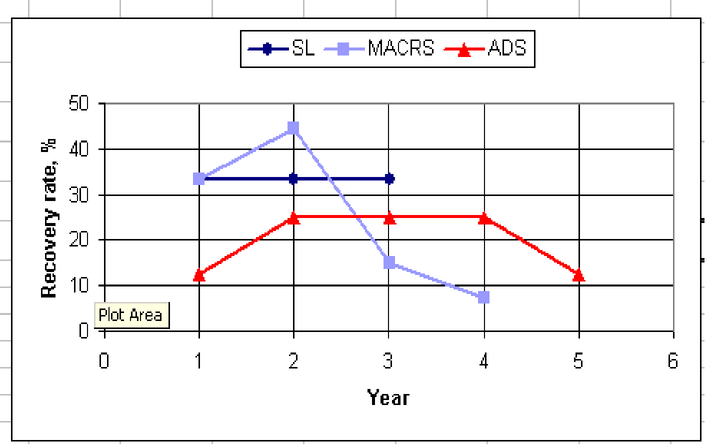
(b) MACRS: sum d values for 3 years: 0.20 + 0.32 + 0.192 = 0.712 (71.2%)
SL: sum the d values for 3 years: 0.05 + 0.1 + 0.1 = 0.25 (25%)

SL depreciates much slower early in the recovery period.

16.35 ADS recovery rates are d = ¼ = 0.25 except for years 1 and 5, which are 50% of this.

	d values (%)		
Year	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

Year	SL	MACRS	ADS
1	33.3	33.33	12.5
2	33.3	44.45	25.0
3	33.3	14.81	25.0
4		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) 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.

Year	Gross* Income	PDA at 15%	50% of TI	Allowed depletion
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 × \$/ounce

16.41 (a) Cost depletion: CD_t = \$3.2/2.5 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

% written off = 490,500/3.2 million = 0.1533 (15.33%)

(c) Undepleted investment after 3 years:

3.2 million – (90,000 + 64,000 + 101,500) = $2,944,500

New cost depletion factor for years 4 and after:

CD_t = $2.9445 million/1.5 million tons
= $1.963 per ton

Cost depletion for years 4 and 5:

Year 4: 60,000(1.963) = $117,780 (> PDA)
Year 5: 65,000(1.963) = $127,595 (< PDA)

Percentage depletion amounts are the same: $105,000 and $130,000

Conclusion: Select CDA for year 4 and PDA in year 5

% written off = $503,280/3.2 million = 0.1573 (15.73%)

16.42 Answer is (b)

16.43 Answer is (c)

16.44 D = (20,000 – 2000)/5
= $3600 per year

Answer is (b)

16.45 D_3 = 40,000(0.144)
= $5760

Answer is (a)

16.46 Depl = 10,000(150)(0.10)
= $150,000

Answer is (d)

16.47 3000 = (20,000 - S) /5
S = $5000

Answer is (c)

16.48 Salvage value does not enter in the calculation of depreciation in the DDB method.

Answer is (a)

16.49 BV = 100,000 – 100,000(0.10 + 0.18 + 0.144 + 0.1152) = $46,080

Answer is (d)

16.50 33,025 = B(0.192)
B = 172,005

Answer is (b)

16.51 CD_t = (70,000 - 20,000)/25,000 = $2.00 per tree

Cost depletion, year 1: 2.00(5000) = $10,000

Answer is (c)

16.52 Total depreciation = first cost – BV after 3 years
= 50,000 – 21,850 = $28,150

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.

$$D_2 = \frac{10 - 2 + 1}{55}(150{,}000 - 15{,}000) = \$22{,}091$$

$$BV_2 = 150{,}000 - \left[\frac{2(10 - 1 + 0.5)}{55}\right](150{,}000 - 15{,}000) = \$103{,}364$$

$$D_7 = \frac{10 - 7 + 1}{55}(150{,}000 - 15{,}000) = \$9818$$

$$BV_7 = 150{,}000 - \left[\frac{7(10 - 3.5 + 0.5)}{55}\right](150{,}000 - 15{,}000) = \$29{,}727$$

(b)

	A	B	C	D
1	Basis =	\$150,000	Salvage at 10% =	\$15,000
2				
3	Year	Depreciation	Book value	
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	

=SYD(150000,15000,10,\$A5)

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:

$$d_4 = \frac{6 - 4 + 1}{21} = 3/21 = 1/7$$

$$D_4 = d_4(B - S)$$
$$= (3/21)(12{,}000 - 1800)$$
$$= \$1457$$

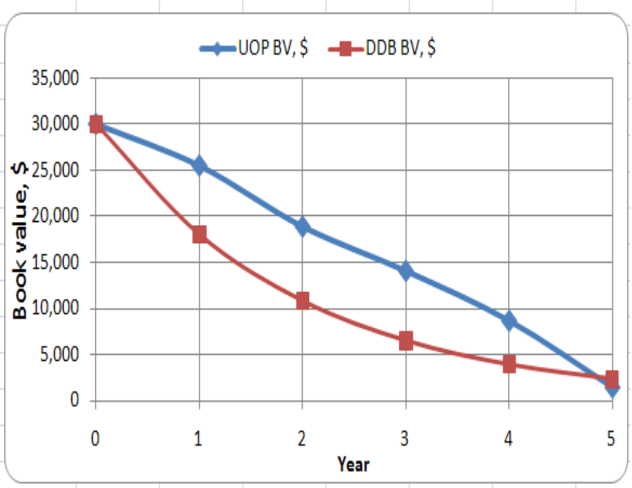
16A.4 D_t = (tests per year t/10,000)(70,000)

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.

	UOP method			DDB method	
Year	Mileage	Depr, \$	UOP BV, \$	Depr, \$	DDB BV, \$
0			30,000		30,000
1	15,000	4,500	25,500	12,000	18,000
2	22,000	6,600	18,900	7,200	10,800
3	16,000	4,800	14,100	4,320	6,480
4	18,000	5,400	8,700	2,592	3,888
5	24,000	7,200	1,500	1,555	2,333



16A.6 B = \$45,000 n = 5 S = \$3000 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], $BV_5 = 45{,}000(1 - 0.4)^5 = 3499 > 3000$

Switching is advisable. Remember to consider S = \$3000 in Equation [16A.8].

t	DDB Method Eq. [16A.7]	DDB Method BV	Switching to SL method Eq. [16A.8]	Larger Depreciation
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:

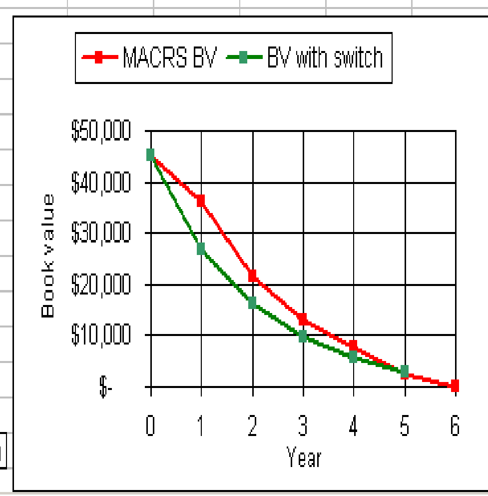
PW_D = 18,000(P/F,18%,1) +. . . + 2,832(P/F,18%,5) = \$30,198

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.

	A	B	C	D	E	F
1						
2		Switching DDB-to-SL		MACRS		
3	Year	Depr.	BV with switch	d rate	Depr.	MACRS BV
4	0		\$ 45,000			\$ 45,000
5	1	\$ 18,000	\$ 27,000	0.2	\$ 9,000	\$ 36,000
6	2	\$ 10,800	\$ 16,200	0.32	\$ 14,400	\$ 21,600
7	3	\$ 6,480	\$ 9,720	0.192	\$ 8,640	\$ 12,960
8	4	\$ 3,888	\$ 5,832	0.1152	\$ 5,184	\$ 7,776
9	5	\$ 2,832	\$ 3,000	0.1152	\$ 5,184	\$ 2,592
10	6			0.0576	\$ 2,592	\$ -
11						
12	PW of Depr.	\$30,198			\$29,128	

=NPV(18%,B5:B9)

=VDB(\$C\$4,3000,5,\$A8,\$A9,2,FALSE)



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

= NPV(12%,B5:B9)+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) $155{,}000(1\text{-}d)^{25} > 50{,}000$

$$1 – d > [\ 50{,}000/155{,}000]^{1/25}$$

$$1 - d > (0.3226)^{0.04} = 0.95575$$
$$d < 1 - 0.95575 = 0.04425$$

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:

$d_{DB,2} = 0.4(1 - 0.2) = 0.32$ (selected)

By Eq. [16A.16] for SL:

$d_{SL,2} = 0.8/4.5 = 0.178$

d_3: DDB: $d_{DB,3} = 0.4(1 - 0.2 - 0.32)$
$= 0.192$ (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: $d_{SL,4} = 0.288/2.5 = 0.1152$ (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.

t	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) NOI = gross income - operating expenses = GI - OE
Taxable income removes depreciation from the NOI amount; TI = GI - OE - D
NOPAT is TI with taxes removed; or NOI with depreciation and taxes removed:
NOPAT = (TI) - taxes = (GI - OE - D) - taxes = (NOI - D) - taxes

17.2 (a) Taxes = 22,250 + 0.39(150,000 – 100,000)
= $41,750

Average rate = [41,750/150,000](100%)
= 27.8%

(b) Taxes = 3,400,000 + 0.35(12,000,000 – 10,000,000)
= $4,100,000

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
TI = Gross income - Expenses - Depreciation
= (1,500,000 + 31,000) – 754,000 – 48,000
= $729,000

Taxes = 113,900 + 0.34(729,000 – 335,000)
= $247,860

Company 2
TI = (820,000 + 25,000) – 591,000 – 18,000
= $236,000

Taxes = 22,250 + 0.39(236,000 – 100,000)
= $75,290

(b) Company 1: 247,860/1.5 million = 16.52%

Company 2: 75,290/820,000 = 9.2%

(c) Company 1
Taxes = (TI)(T_e) = 729,000(0.34) = $247,860
% error with graduated tax = 0%

Company 2
Taxes = 236,000(0.34) = $80,240

$$\% \text{ error} = \frac{80,240 - 75,290}{75,290}(100\%) = +6.6\%$$

17.6 Taxes on $250,000 = 22,250 + 0.39(150,000)
= $80,750

(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

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]

NOPAT = TI - taxes
= 200,000 – 0.39(85,000) – 0.34(265,000)
= $76,750

17.7 $T_e = 0.072 + (1 – 0.072)(0.35) = 0.3968$

TI = 7.5 million – 4.3 million = $3.2 million

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)

Average federal rate = (18,850/90,000)(100%)
= 20.9%

(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

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

Tax difference = 58,500 – 58,110 = $390 (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

$0.2486 = x + (1-x)(0.23)$
$x = 0.0186/0.77 = 0.0242$ (2.42%)

(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 – 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.

17.13

$$CFBT = CFAT + taxes$$
$$CFBT = CFAT + TI(T_e)$$
$$CFBT = CFAT + (GI – OE - D)T_e$$
$$CFBT = CFAT + (CFBT - D)T_e$$
$$CFBT(1 - T_e) = CFAT - DT_e$$
$$CFBT = [CFAT – D(T_e)]/(1 - T_e)$$

17.14 $CFAT = CFBT - (CFBT-D)T_e$

$600,000 = CFBT - (CFBT - 350,000)0.36$

$CFBT = [600,000 - 350,000(0.36)]/(1 – 0.36) = \$740,625$

17.15 $CFAT = GI – OE – P + S – (GI – OE –D)T_e$

(a) P and S = 0

$D = 200,000(0.0741) = \$14,820$

$CFAT = 100,000 – 50,000 – (100,000 – 50,000 – 14,820)(0.40)$
$= \$35,928$

(b) S = $20,000

$D = 200,000(0.0741) = \$14,820$

$CFAT = 100,000 – 50,000 + 20,000 - (100,000 – 50,000 – 14,820)(0.40)$
$= \$55,928$

17.16 $T_e = 0.065 + (1 - 0.065)(0.35) = 0.39225$

All monetary amounts are in $ million units

(a) $CFAT = GI – OE – TI(T_e) = 48 – 28 – (48 - 28 - 8.2)(0.39225)$
$= 20 – 11.8(0.39225)$
$= \$15.37$ ($15.37 million)

(b) Taxes = (48 – 28 – 8.2)(0.39225) = $4.628 million

% of revenue = 4.628/48 = 9.64%

(c) $NPAT = NOPAT = TI(1 - T_e) = (48-28-8.2)(1 - 0.39225)$
$= \$7.17$ ($7.17 million)

17.17 CFBT = CFAT + 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 million

$T_e = 0.08 + (1-0.08)(0.20) = 0.264$

$1- T_e = 0.736$

Year 1: GI_1 = [2.5 million + 650,000(0.736) – 650,000(0.264)]/0.736
= $3,813,587

Year 2: GI_2 = [2.5 million + 900,000(0.736) – 900,000(0.264)]/0.736
= $3,973,913

Year 3: GI_3 = [2.5 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

PW = -1900 + 700(P/F,15.4%,1) + … + 750(P/F,15.4%,4)
= -1900 + 700(0.867) + 800(0.751) + 400(0.651) + 750(0.564)
= $-9

AW = -9(A/P,15.4%,4) = -9(0.3531)
= $-3 ($-3,000)

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.)

TI = GI – OE - D

CFAT = CFBT - taxes

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%.

AW = [-1900 + 677(P/F,10%,1) + … + 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 ($61,000)

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
1	AT MARR =	10%		BT MARR =	15.38%				
2									
3	Year	GI	OE	P and S	CFBT	Depr	TI	Taxes	CFAT
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
10	Justified?				No				Yes
11	Actual ROR				15.1%				14.7%
12	Approx ROR								9.8%
13									
14									
15									

= 10%/(1-0.35)

Prob 17.19

Prob 17.18

Prob 17.20

Prob 17.21

= E11*(1-0.35)

17.22 CFBT = GI - OE - P + S (column E)
TI = CFBT – D
Taxes = 0.4(TI)
CFAT = CFBT – taxes (column J)
NOPAT = TI – taxes (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

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

Year 1-3: Taxes = (GI – OE – D)(T_e)
= (32,000-10,000-20,000)(0.31)
= \$620
Years 4-6: Taxes = (GI – OE)(T_e)
= (32,000-10,000)(0.31)
= \$6820

Total taxes = 3(620) + 3(6820) = \$22,320

PW_{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

Recovery over 6 years: SL depreciation is 60,000/6 = \$10,000 per year

Years 1-6: Taxes = (GI – OE – D)(T_e)
= (32,000-10,000-10,000)(0.31) = \$3720

Total taxes = 6(3720) = \$22,320

PW_{tax} = 3720(P/A,12%,6) = 3720(4.1114)
= \$15,294

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 – taxes
NOPAT = TI – 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, Taxes = TI(0.35)

Year	CFBT	D	TI	Taxes
1-3	\$80,000	\$50,000	\$30,000	\$10,500

PW_{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_{tax} = 10,502(P/F,15%,1) + ... - 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

MACRS is 10,502 + … - 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_{tax} = 13,300(P/F,8%,1) + 4180(P/F,8%,2) + … + 28,500(P/F,8%,8)
= $102,119

Total taxes = $152,000

Straight line depreciation

Depreciation is 200,000/8 = $25,000 per year

Taxes = (75,000 – 25,000)(0.38) = $19,000 per year

Total taxes = 8(19,000) = $152,000

PW_{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) + … + 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 = Selling Price – BV = 100,000 – 0 = \$100,000

DR is taxed as regular taxable income

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_{tax} = 1500(P/A,9%,5)
= \$5835

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

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) + … + 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) + … + 13,500(P/F,9%,5)
= $7669

PW_{CFAT} = -100,000 + 27,500(P/F,9%,1) +…+ 31,500(P/F,9%,5)
= -100,000 + 27,500(0.9174) + …+ 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) + … + 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) + … + 7,500(P/F,9%,5)
= $8427

PW_{CFAT} = -100,000 + 29,500(P/F,9%,1) +…+ 37,500(P/F,9%,5)
= -100,000 + 29,500(0.9174) + …+ 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%

$20,000 salvage is extra TI in year 5.

= NPV(9%,O4:O8) + O3

	A	B	C	D	E
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_e) = 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 million) = $180,000

Taxes = 180,000(0.35) = $63,000

(d) CL = 5000 – 500 = $4500
TI = $–4500

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

Before-tax ROR = 0.07/(1 - 0.3677) = 0.111 (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% (spreadsheet)

After-tax ROR estimate = 25.0(1 – 0.35) = 16.25%

17.43 0.12 = 0.08/(1 - tax rate)
1 - tax rate = 0.667
Tax rate = 0.333 (33.3%)

17.44 Small company: After-tax ROR = 0.18(1 - 0.28) = 0.1296 (12.96%)
Conclusion: Accept at after-tax MARR = 12%

Large corporation: After-tax ROR = 0.18(1 - 0.34) = 0.1188 (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

Taxes = (20,000 – 18,000)(0.34) = $680

CFAT = 20,000 – 680 = $19,320

AW_A = -100,000(A/P,7%,5) + 19,320 + 10,000(A/F,7%,5)
= $-3330

Method B: Years 1-5: CFBT = 45,000 – 6,000 = 39,000

D = (150,000 - 20,000)/5 = $26,000

Taxes = (39,000 – 26,000)(0.34) = $4420

CFAT = 39,000 – 4420 = $34,580

AW_A = -150,000(A/P,7%,5) + 34,580 + 20,000(A/F,7%,5)
= $-1474

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

PW_B = -22,000 – 1500(P/A,14%,10) + 5000(P/F,14%,10)
= -22,000 – 1500(5.2161) + 5000(0.2697)
= $-28,476

Select B with a slightly smaller PW value.

(b) All costs generate tax savings.

<u>Machine A</u>

Annual depreciation = (15,000 – 3,000)/10 = $1200

Tax savings = (AOC + D)0.5 = 4200(0.5) = $2100

CFAT = –3000 + 2100 = $–900

PW_A = –15,000 – 900(P/A,7%,10) + 3000(P/F,7%,10)
= –15,000 – 900(7.0236) + 3000(0.5083)
= $–19,796

<u>Machine B</u>

Annual depreciation = (22,000 – 5000)/10 = $1700

Tax savings = (1500 + 1700) (0.50) = $1600

CFAT = –1500 + 1600 = $100

PW_B = –22,000 + 100(P/A,7%,10) + 5000(P/F,7%,10)
= –22,000 + 100(7.0236) + 5000(0.5083)
= $–18,756

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 + 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

PW_A = –15,000 + 0 + 900(P/F,7%,2) + ... – 1,500(P/F,7%,9)
= $–18,536

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

$PW_B = –22,000 + 1450(P/F,7\%,1) + ... + 2500(P/F,7\%,10)$
$= \$–16,850$

Select machine B, as above.

17.47 Alternative A

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

$PW_A = -8000 + 3167(P/F,8\%,1) + 3522(P/F,8\%,2) + 2574(P/F,8\%,3) + 237(P/F,8\%,4)$
$= \$169$

Alternative B

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.

<u>Year 1</u>

Taxes = (1,500 - 500) (0.30) = \$300
CFAT = 1,500 - 300 = \$1,200

<u>Years 2 - 5</u>

Taxes = (300 - 500) (0.30) = \$–60
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 % (interpolation between 2% 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) + ... + 296(P/F,i*,5)

i* = 1.71% (interpolation between 1% 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								5-year ROR is =IRR(L4:L9)				
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 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 - 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, next year = -70,000 - 69,960 = -139,960

Taxes, next year = -139,960(0.35) = $-48,986 (tax savings)

CFAT 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

Annual tax = (-OE – D)(T_e)
= (-7000 – 5000)(0.35)
= $-4200 (savings)

CFAT = CFBT – 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.

Defender BV_3 = 45,000 – 3(5000) = \$30,000
SP = \$35,000
DR = SP – BV = 5,000
Tax on DR = 5,000(0.35) = \$1750

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

PW_C = -25,750 – 2400(P/F,12%,1) - … - 4578(P/F,12%,4)
= \$-34,787

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

DR = 35000-(45000 - 3(5000)) = 5000
DR tax = 5000(0.35) = 1750
First cost relation is:
= -24000 - 0.35*(35000-(45000-3*(5000)))

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
Tax on DR = 25,000(0.3) = \$7500

Challenger first cost = -75,000 – 7500 = \$-82,500
SL depreciation = (75,000-15,000)/10 = \$6000 per year

Years 1-10, CFAT = CFBT – (CFBT - D)(T_e)
= 15,000 – (15,000 – 6000)(0.3)
= \$12,300

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

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 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

Year 1: TI = –120,000 – 266,640 + 66,640 = $–320,000
Year 2: TI = –120,000 – 355,600 + 222,240 = $–253,360
Year 3: TI = –120,000 – 118,480 + 140,720 = $– 97,760

CFAT = –OE + SP – taxes (where negative taxes are a tax savings)

Year 1: -120,000 + 600,000 – (-112,000) = $592,000
Year 2: -120,000 + 400,000 – (-88,676) = $368,676
Year 3: -120,000 + 200,000 – (-34,216) = $114,216

AW_{C1} = –800,000(A/P,10%,1) + 592,000
= –800,000 (1.10) + 592,000
= $– 288,000

AW_{C2} = –800,000(A/P,10%,2)+[592,000(P/F,10%,1) + 368,676(P/F,10%,2)](A/P,10%,2)
= –800,000(0.57619) + [592,000(0.9091) + 368,676(0.8264)](0.57619)
= $+24,696

AW_{C3} = –800,000(A/P,10%,3) + [592,000(P/F,10%,1) + 368,676(P/F,10%,2) + 114,216(P/F,10%,3)](A/P,10%,3)
= –800,000(0.40211) + [592,000(0.9091) + 368,676(0.8264) + 114,216(0.7513)](0.40211)
= $+51,740

Selection of best option: Determine AW for each option first.

Summary of cost/year and project AW

	Year			
Option	1	2	3	AW
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

First cost = Sale + Upgrade
= 15,000 + 9000
= $24,000

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

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

<u>Challenger</u>

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)

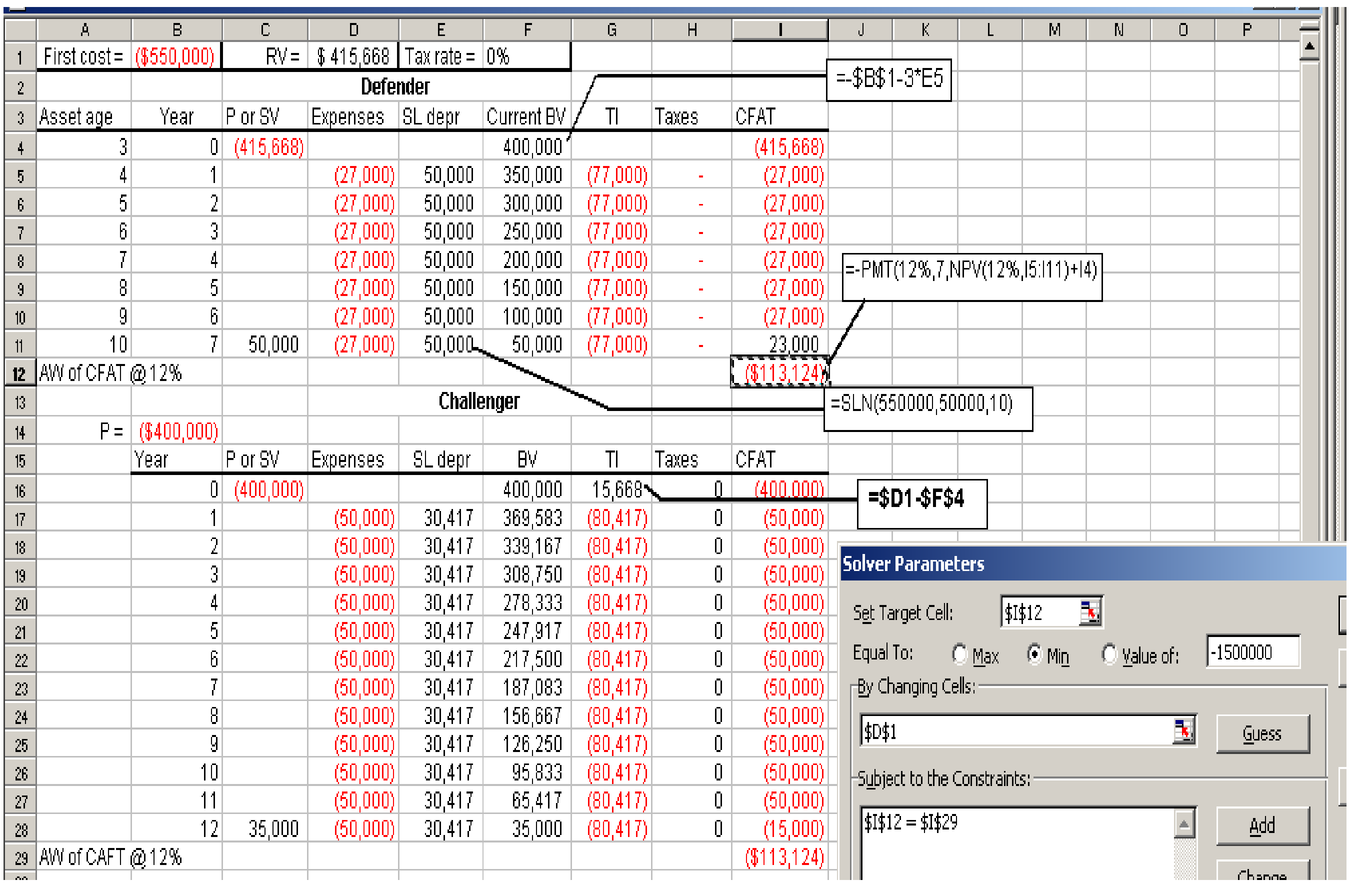
AW_C = –46,000(A/P,12%,5) – 1000
= –46,000(0.27741) – 1000
= \$–13,761

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
1	First cost =	($550,000)	RV =	$ 415,668	Tax rate =	0%			
2				Defender					
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					Challenger				
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)

(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.

Year	GI	OE	P	D	TI	Taxes	CFAT	NOPAT	BV	Cost of Inv. Capital	EVA
0			-300,000				-300,000		300,000		0
1	200,000	-80,000		99,990	20,010	7,004	112,997	13,007	200,010	-29,250	-16,244
2	200,000	-80,000		133,350	-13,350	-4,673	124,673	-8,678	66,660	-19,501	-28,178
3	200,000	-80,000		44,430	75,570	26,450	93,551	49,121	22,230	-6,499	42,621
4	200,000	-80,000		22,230	97,770	34,220	85,781	63,551	0	-2,167	61,383
AW @ 9.75%							$11,408				$11,407

= -PMT(9.75%,4,NPV(9.75%,H4:H7)+H3)

= F7 - G7

= -0.0975*J6

= I7 + K7

17.61 Depreciation is SL: Hong Kong: 4.2 million/8 = $525,000
Japan: 3.6 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.

HONG KONG

Year	GI - OE	P	D	TI	NOPAT	BV	Inv Cap Cost	EVA	CFAT
0		-4,200,000				4,200,000			-4,200,000
1	1,500,000		525,000	975,000	682,500	3,675,000	-336,000	346,500	1,207,500
2	1,800,000		525,000	1,275,000	892,500	3,150,000	-294,000	598,500	1,417,500
3	2,100,000		525,000	1,575,000	1,102,500	2,625,000	-252,000	850,500	1,627,500
4	2,400,000		525,000	1,875,000	1,312,500	2,100,000	-210,000	1,102,500	1,837,500
5	2,700,000		525,000	2,175,000	1,522,500	1,575,000	-168,000	1,354,500	2,047,500
6	3,000,000		525,000	2,475,000	1,732,500	1,050,000	-126,000	1,606,500	2,257,500
7	3,300,000		525,000	2,775,000	1,942,500	525,000	-84,000	1,858,500	2,467,500
8	3,600,000		525,000	3,075,000	2,152,500	0	-42,000	2,110,500	2,677,500
			4,200,000					$1,127,328	$1,127,328

= E11*(1-0.3)

= -0.08*G10

JAPAN

Year	GI - OE	P	D	TI	NOPAT	BV	Inv Cap Cost	EVA	CFAT
0		-3,600,000				3,600,000			-3,600,000
1	1,500,000		720,000	780,000	546,000	2,880,000	-288,000	258,000	1,266,000
2	1,800,000		720,000	1,080,000	756,000	2,160,000	-230,400	525,600	1,476,000
3	2,100,000		720,000	1,380,000	966,000	1,440,000	-172,800	793,200	1,686,000
4	2,400,000		720,000	1,680,000	1,176,000	720,000	-115,200	1,060,800	1,896,000
5	2,700,000		720,000	1,980,000	1,386,000	0	-57,600	1,328,400	2,106,000
6	3,000,000		0	3,000,000	2,100,000	0	0	2,100,000	2,100,000
7	3,300,000		0	3,300,000	2,310,000	0	0	2,310,000	2,310,000
8	3,600,000		0	3,600,000	2,520,000	0	0	2,520,000	2,520,000
			3,600,000					$1,224,312	$1,224,312

AW of EVA:
=-PMT(8%,8,NPV(8%,I18:I25))

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											= J12 - K12		
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

17.68 Average VAT rate = taxes paid/value of goods and services
= 235.720/(350 + 870 + 620 + 90 +50)
= 235.720/1980.0
= 0.11.91 (11.91%)

17.69 Taxes sent = amount collected – amount paid
= 9,200,000(0.125) – 235,720 (from problem 17.67)
= $914,280

17.70 Taxes collected = taxes sent by suppliers + taxes sent by Ajinkya
= 235,720 + 914,280
= $1,150,000

or Taxes collected = 9,200,000(0.125)
= $1,150,000

17.71 Answer is (c)

17.72 Answer is (d)

17.73 Savings = 16,000(0.35) = $5600

Answer is (b)

17.74 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 Taxes = (55,000 + 4,000 - 13,000 - 11,000) (0.25) = $8750

Answer is (b)

17.78 Answer is (b)

17.79 CFAT = GI – OE – TI(T_e)
26,000 = 30,000 – TI(0.40)
TI = (30,000 – 26,000)/0.40 = $10,000

Taxes = TI(T_e) = 10,000(0.40) = $4000

TI = (GI - OE – D)
10,000 = (30,000 – D)
D = $20,000

Answer is (d)

17.80 Before-tax ROR = After-tax ROR/(1- T_e)
= 11.9%/(1-0.34)
= 18.0%

Answer is (c)

17.81 BV_5 = 100,000(0.0576) = $5760

DR = 22,000 – 5760 = $16,240

Tax on DR = 16,240(0.30) = $4872

Cash flow = 22,000 – 4872
= $17,128

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											
15				50% debt and 50% equity financing							
16			Debt financing (loan)		Equity	MACRS			Taxes		
17	Year	GI - E	Interest[1]	Principal	investment	rate	Depr.	TI	@ 35%	CFAT	
18	0				($750,000)	-				($750,000)	
19	1	$600,000	($45,000)	($150,000)		0.2000	$300,000	$255,000	$89,250	$315,750	
20	2	$600,000	($45,000)	($150,000)		0.3200	$480,000	$75,000	$26,250	$378,750	
21	3	$600,000	($45,000)	($150,000)		0.1920	$288,000	$267,000	$93,450	$311,550	
22	4	$600,000	($45,000)	($150,000)		0.1152	$172,800	$382,200	$133,770	$271,230	
23	5	$600,000	($45,000)	($150,000)		0.1152	$172,800	$382,200	$133,770	$271,230	
24	6	$600,000			$0	0.0576	$86,400	$513,600	$179,760	$420,240	
25	Totals					1.0000	$1,500,000		$656,250	$1,218,750	
26	PW at 10%									$675,015	
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	GI - 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.

EVA = NPAT – interest on invested capital (column M)

NPAT = TI – taxes

$(\text{Interest on invested capital})_t = i(\text{BV in the previous year})$
$= 0.10(\text{BV}_{t-1})$

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 (ROR < 15%)

\$165,000: PW = -500,000 + 165,000(P/A,15%,5)
= -500,000 + 165,000(3.3522)
= \$53,113 (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 (> \$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 (> 20% 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 (< 20% 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 (< 20% 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 $AW_{current}$ = \$-63,000

$AW_{10,000}$ = -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

$AW_{13,000}$ = -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

$AW_{18,000}$ = -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

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_{Cnt} = \$-175,000

AW_{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 (< \$-175,000)

AW_{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 (> \$-175,000)

Decision *is sensitive* to salvage value.

18.8 Required AW < \$5.7 million

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 (< \$-5,700,000)

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 (< \$-5,700,000)

The decision is *not sensitive* since both AW values are below \$5.7 million.

18.9 AW_{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)

AW_{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 (> \$-62,849)

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 PW = –P + (60,000 – 5000)(P/A,10%,5)
= –P + 55,000(3.7908)
= –P + 208,494

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 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

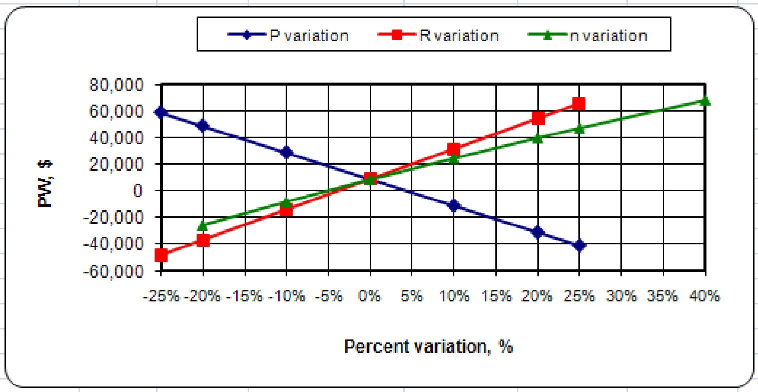
Percent variation	R value, $	PW, $
-25%	45,000	-48,368
-20	48,000	-36,996
-10	54,000	-14,251
0	60,000	8,494
10	66,000	31,239
20	72,000	53,984
25	75,000	65,356

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.

			Current PW computation		PW values for sensitivity chart			
P value	R value	n value	Variation	PW	% variation	P variation	R variation	n variation
-150000	45000		-25%		-25%	58,493	-48,369	
-160000	48000	4.0	-20%	-25,657	-20%	48,493	-36,996	-25,657
-180000	54000	4.5	-10%	-8,175	-10%	28,493	-14,251	-8,175
-200000	60000	5.0	0%	8,493	0%	8,493	8,493	8,493
-220000	66000	5.5	10%	24,386	10%	-11,507	31,238	24,386
-240000	72000	6.0	20%	39,539	20%	-31,507	53,983	39,539
-250000	75000	6.3	25%	46,849	25%	-41,507	65,355	46,849
		7.0	40%	67,763	40%			67,763



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

Future worth of deposits: F = A(F/A,i,n) = 27,185(F/A,6%,20)
= 27,185(36.7856)
= $1,000,016

Withdrawals: R = F(i) = 1,000,016(0.06)
= $60,000 per year forever

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.

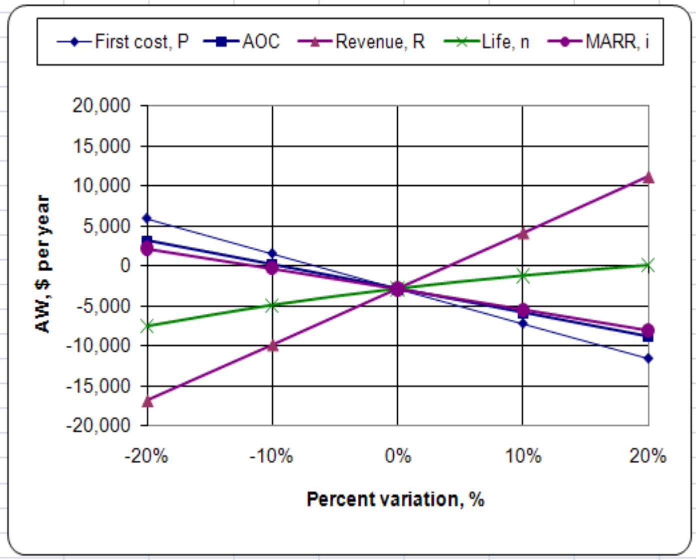
Spreadsheet solution

	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.

AW at 15% =	-$2,850		S = $20,000 for all scenarios		
	= -PMT(15%,10,-PV(15%,10,40000,20000)-220000)				
% change	First cost, P	AOC	Revenue, R	Life, n	MARR, i
-20%	-176,000	-24,000	56,000	8	12.0
-10%	-198,000	-27,000	63,000	9	13.5
0%	-220,000	-30,000	70,000	10	15.0
10%	-242,000	-33,000	77,000	11	16.5
20%	-264,000	-36,000	84,000	12	18.0
	Annual Worth Analysis				
% change	First cost, P	AOC	Revenue, R	Life, n	MARR, i
-20%	5,917	3,150	-16,850	-7,570	2,203
-10%	1,533	150	-9,850	-4,915	-297
0%	-2,850	-2,850	-2,850	-2,850	-2,850
10%	-7,234	-5,850	4,150	-1,214	-5,453
20%	-11,618	-8,850	11,150	104	-8,103
	AW equations for +20% change:				
First cost, P	= -PMT(15%,10,-PV(15%,10,40000,20000)+$B9)				
AOC	= -PMT(15%,10,-PV(15%,10,70000+C9,20000)-220000)				
Revenue, R	= -PMT(15%,10,-PV(15%,10,$D9-30000,20000)-220000)				
Life, n	= -PMT(15%,$E9,-PV(15%,$E9,40000,20000)-220000)				
MARR, i	= -PMT($F9%,10,-PV($F9%,10,40000,20000)-220000)				



18.17 Determine AW values at different savings, s.

$$AW_A = -50{,}000(A/P,10\%,5) – 7500 + 5{,}000(A/F,10\%,5) + s$$
$$= -50{,}000(0.2638) – 7500 + 5000(0.1638) + s$$
$$= -19{,}871 + s$$

$$AW_B = -37{,}500(A/P,10\%,5) – 8000 + 3700(A/F,10\%,5) + s$$
$$= -37{,}500(0.2638) – 8000 + 3700(0.1638) + s$$
$$= -17{,}286 + s$$

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 ± 30% changes in (a), (b) and (c) on one graph.

(1) Face value, V

$$PW = V(P/F,4\%,20) + 450(P/A,4\%,20)$$
$$= V(0.4564) + 6116$$

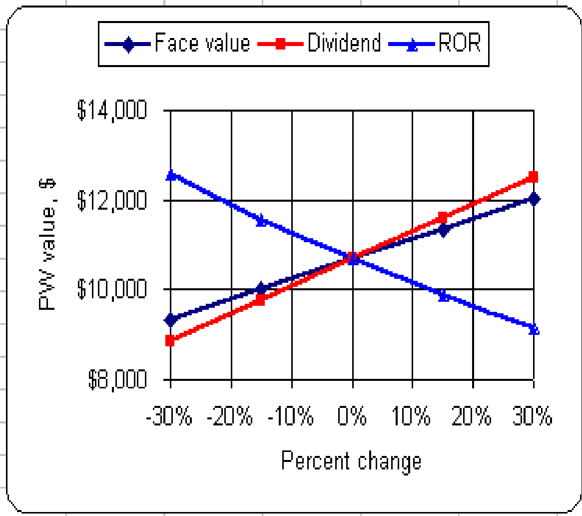
(2) Dividend rate, b

$$PW = 10{,}000(P/F,4\%,20) + (10{,}000/2)(b)(P/A,4\%,20)$$
$$= 10{,}000(0.4564) + b(5000)(13.5903)$$
$$= 4564 + b(67{,}952)$$

(3) Nominal rate, r

$$PW = 10{,}000(P/F,r,20) + 450(P/A,r,20)$$

	A	B	C	D
6	% change	Face value	Dividend	ROR
7	-30%	$ 7,000	$ 315.00	2.8%
8	-15%	$ 8,500	$ 382.50	3.4%
9	0%	$ 10,000	$ 450.00	4.0%
10	15%	$ 11,500	$ 517.50	4.6%
11	30%	$ 13,000	$ 585.00	5.2%
12				
13		Present worth analysis*		
14				
15		PW for	PW for	PW for
16	% change	Face value	Dividend	ROR
17	-30%	$ 9,310	$ 8,845	$ 12,577
18	-15%	$ 9,995	$ 9,762	$ 11,578
19	0%	$ 10,680	$ 10,680	$ 10,680
20	15%	$ 11,364	$ 11,597	$ 9,871
21	30%	$ 12,049	$ 12,514	$ 9,142
22				
23	PV function used. For example:			
24	in B17: =-PV(4%,20,450,7000)			
25	in D21: =-PV(5.2%,20,450,10000)			



(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 $AW_{Contract}$ = $-190,000

$AW_{Optimistic}$ = -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 (< $-190,000; purchase equipment)

$AW_{Most\ Likely}$ = -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 (< $-190,000; purchase equipment)

$AW_{Pessimistic}$ = -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 (> $-190,000; do not purchase equipment)

The optimistic and most likely estimates favor purchasing the equipment, but the pessimistic estimate does not.

18.20 AW_{Lease} = \$-30,000 per year

$AW_{Pessimistic}$ = -880,000(A/P,10%,20) + 900,000(A/F,10%,20)
= -880,000(0.11746) + 900,000(0.01746)
= \$-87,651

$AW_{Most\ Likely}$ = -880,000(A/P,10%,20) + 1,400,000(A/F,10%,20)
= -880,000(0.11746) + 1,400,000(0.01746)
= \$-78,920

$AW_{Optimistic}$ = -880,000(A/P,10%,20) + 2,400,000(A/F,10%,20)
= -880,000(0.11746) + 2,400,000(0.01746)
= \$-61,461

It would not be cost-effective to purchase the building under any resale-value scenario

18.21 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

AW_{D103} 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 (> \$-135,143)

AW_{D103} 3-year life = -400,000(A/P,10%,3) – 4000 + 40,000(A/F,10%,3)
= -400,000(00.40211) – 4000 + 40,000(0.30211)
= \$-152,760 (> \$-135,143)

AW_{D103} 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 (< \$-135,143)

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)

PW_M = –100,000 + 15,000(P/A,8%,20)
= –100,000 + 15,000(9.8181)
= \$47,272

PW_Q = –110,000 + 19,000(P/A,8%,20)
= –110,000 + 19,000(9.8181)
= \$76,544

MARR = 10% (Most Likely)

PW_M = –100,000 + 15,000(P/A,10%,20)
= –100,000 + 15,000(8.5136)
= $27,704

PW_Q = –110,000 + 19,000(P/A,10%,20)
= –110,000 + 19,000(8.5136)
= $51,758

MARR = 15% (Optimistic)

PW_M = –100,000 + 15,000(P/A,15%,20)
= –100,000 + 15,000(6.2593)
= $–6111

PW_Q = –110,000 + 19,000(P/A,15%,20)
= –110,000 + 19,000(6.2593)
= $8927

(b) n = 16: Expanding economy (Optimistic)

n = 20(0.80) = 16 years

PW_M = –100,000 + 15,000(P/A,10%,16)
= –100,000 + 15,000(7.8237)
= $17,356

PW_Q = –110,000 + 19,000(P/A,10%,16)
= –110,000 + 19,000(7.8237)
= $38,650

n = 20: Expected economy (Most likely)

PW_M = $27,704 (From part (a))

PW_Q = $51,758 (From part (a))

n = 22: Receding economy (Pessimistic)

n = 20(1.10) = 22 years

PW_M = –100,000 + 15,000(P/A,10%,22)
= –100,000 + 15,000(8.7715)
= $31,573

PW_Q = –110,000 + 19,000(P/A,10%,22)
= –110,000 + 19,000(8.7715)
= $56,659

(c) Observing the PW values, plan M always has a lower PW value, so it is not accepted and plan Q is.

18.23 E(X) = 600,000(0.20) + 800,000(0.50) + 900,000(0.30)
= $790,000

18.24 E(X) = 20,000(0.32) + 28,000(0.45) + 34,000(0.13) + 0.10(-5,000)
= $22,920

18.25 E(X) = (0.13)[1,500,000 + 1,900,000 + 2,400,000)]/3
= $251,333

18.26 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

18.27 E(X) = 3(0.4) + 4(0.3) + 5(0.2) + 6(0.1)
= 4.0

18.28 (a) E(cycle time) = (1/4)(10 + 20 + 30 + 50) = 27.5 seconds

(b) E(cycle time) = (1/3)(10 + 20 + 30) = 20 seconds

% reduction = (27.5 – 20)/27.5
= 27.3%

18.29 Solve for PW_{high} from E(PW)

E(PW) = 5875 = 3200(0.3) + (PW_{high})(0.7)
PW_{high} = $7021

18.30 E(i) = 1/20[(-8)(1) + (-5)(1) + 0(5) + ... + 15(3)]
= 103/20
= 5.15%

18.31 E(FW) = 0.20(300,000 – 25,000) + 0.6(50,000)
= $85,000

18.32 Determine E(AW) after calculating E(revenue).

E(revenue) = [days)(climbers)(income/climber)](probability)
= [(120)(350)(5)](0.3) + [(120)(350)(5) + 30(100)(5)](0.5)
+ [(120)(350)(5) + (45)(100)(5)](0.2)
= 63,000 + 112,500 + 46,500
= $222,000

E(AW) = –375,000(A/P,12%,10) – 25,000[(P/F,12%,4) + (P/F,12%,8)]
×(A/P,12%,10) – 56,000 + 222,000
= –375,000(0.17698) – 25,000[(0.6355) + (0.4039)](0.17698) + 166,000
= $95,034

The mock mountain should be constructed.

18.33 Determine E(PW) after calculating the PW of E(revenue)

E(revenue) = P(slump)(revenue over 3-year periods)

PW[E(revenue)] = PW[P(slump)(revenue 1st 3 years)
+ P(slump) (revenue 2nd 3 years)
+ P(expansion)(revenue 1st 3 years)
+ P(expansion)(revenue 2nd 3 years)]

= 0.5[20,000(P/A,8%,3)] + 0.2[20,000(P/A,8%,3)
×(P/F,8%,3)] + 0.5[35,000(P/A,8%,3)]
+ 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

E(PW) = -200,000 + 200,000(0.12) (P/F,8%,6) + PW[E(revenue)]
= -200,000 + 15,125 + 136,333
= $-48,542

No, less than an 8% return is expected.

18.34 AW = annual loan payment + (damage) × P(rainfall amount or greater)

Subscript on AW indicates rainfall amount.

$AW_{2.0}$ = –200,000(A/P,6%,10) + (–50,000)(0.3)
= –200,000(0.13587) –50,000(0.3)
= $–42,174

$AW_{2.25}$ = –225,000(A/P,6%,10) + (–50,000)(0.1)
= –300,000(0.13587) –50,000(0.1)
= $–35,571

$AW_{2.5}$ = –300,000(A/P,6%,10) + (–50,000)(0.05)
= –350,000(0.13587) –50,000(0.05)
= $–43,261

$AW_{3.0}$ = –400,000(A/P,6%,10) + (–50,000)(0.01)
= –400,000(0.13587) –50,000(0.01)
= $–54,848

$AW_{3.25}$ = –450,000(A/P,6%,10) + (–50,000)(0.005)
= –450,000(0.13587) –50,000(0.005)
= $–61,392

Build a wall to protect against a rainfall of 2.25 inches with an expected AW = $– 35,571.

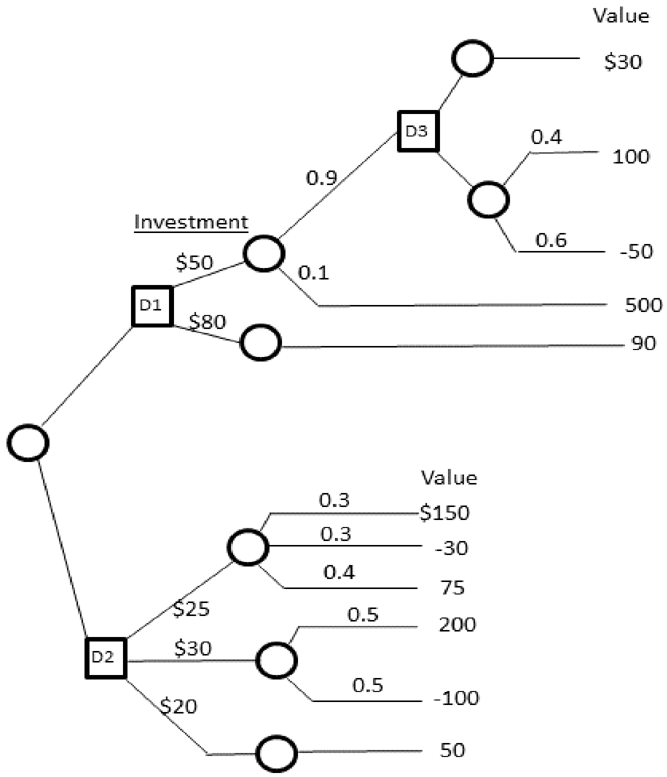
18.35 Compute the expected value for each outcome and select the maximum for D3.

Top node: 0.4(55) + 0.30(–30) + 0.30(10) = 16.0

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(value) = 16.0.

18.36



Maximize the value at each decision node.

D3: Top: E(value) = $30
Bottom: E(value) = 0.4(100) + 0.6(–50) = $10

Select top at D3 for $30

D1: Top: 0.9(D3 value) + 0.1(final value)
0.9(30) + 0.1(500) = $77

At D1, value = E(value) - investment

Top: 77-50 = $27 (maximum)
Bottom: 90 – 80 = $10

Select top at D1 for $27

D2: Top: E(value) = 0.3(150 – 30) + 0.4(75) = $66
Middle: E(value) = 0.5(200 – 100) = $50
Bottom: E(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,

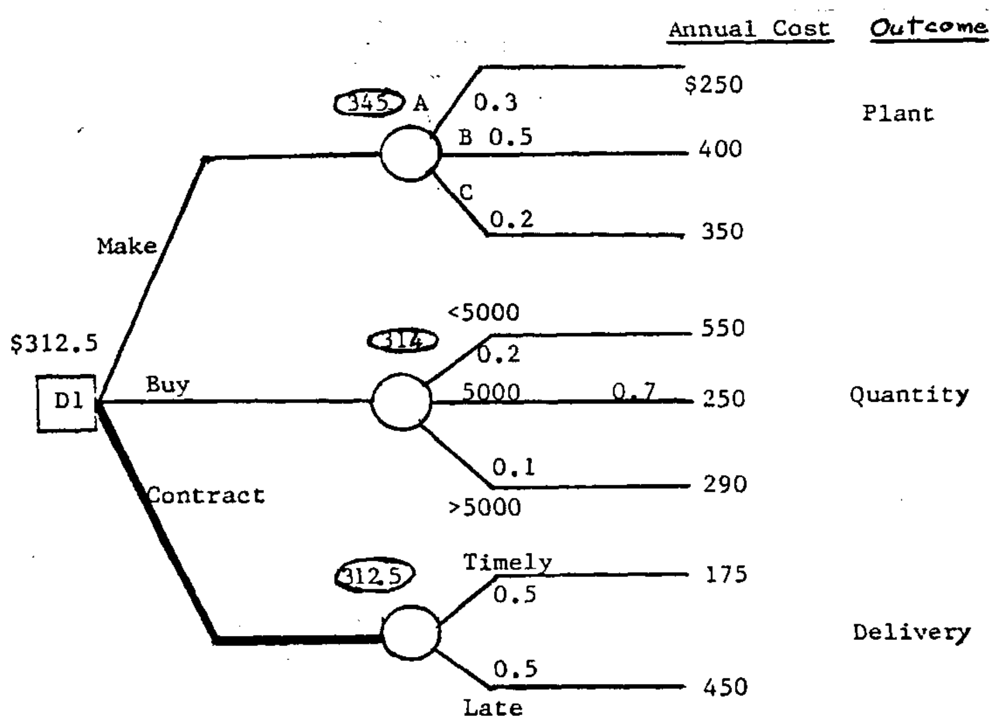
E(PW of D4,x) = –200 + 0.7[50(P/A,15%,3)] + 0.3[40(P/F,15%,1)
+30(P/F,15%,2) + 20(P/F,15%,3)]
= –98.903 (\$–98,903)

E(PW of D4,y) = –75 + 0.45[30(P/A,15%,3) + 10(P/G,15%,3)]
+0.55[30(P/A,15%,3)]
= 2.816 (\$2816)

E(PW of D4,z) = –350 + 0.7[190(P/A,15%,3) – 20(P/G,15%,3)]
+ 0.3[–30(P/A,15%,3)]
= –95.880 (\$–95,880)

Select decision branch y; it has the largest E(PW)

18.38 Select the minimum E(cost) alternative. All monetary units are times $-1000.



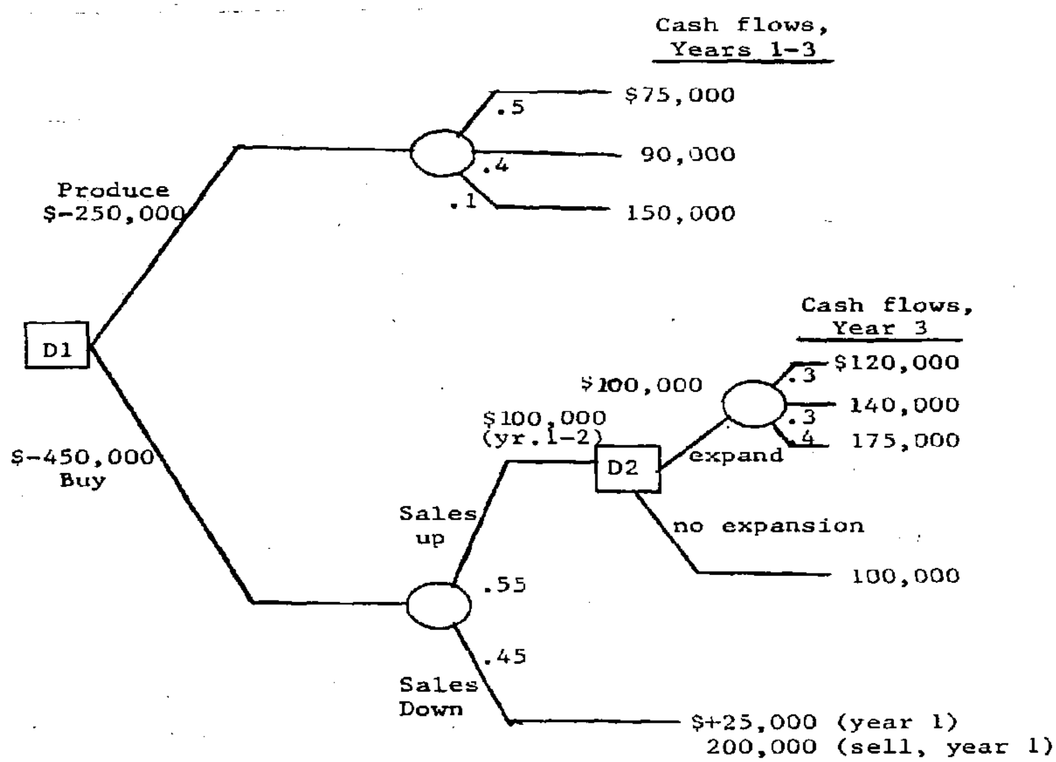
Make: E(cost of plant) = 0.3(250) + 0.5(400) + 0.2(350)
= $345 ($345,000)

Buy: E(cost of quantity) = 0.2(550) + 0.7(250) + 0.1(290)
= $314 ($314,000)

Contract: E(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.

<u>Expansion option</u>

(PW for D2, $120,000) = –100,000 + 120,000(P/F,15%,1)
= $4352
(PW for D2, $140,000) = –100,000 + 140,000(P/F,15%,1)
= $21,744
(PW for D2, $175,000) = $52,180
E(PW) = 0.3(4352 + 21,744) + 0.4(52,180) = $28,700

<u>No expansion option</u>

(PW for D2, $100,000 = $100,000(P/F,15%,1) = $86,960
E(PW) = $86,960

Conclusion at D2: Select no expansion option

(c) Complete rollback to D1 considering 3 year cash flow estimates.

Produce option, D1

E(PW of cash flows) = [0.5(75,000) + 0.4(90,000) + 0.1(150,000](P/A,15%,3)
= $202,063

E(PW for produce) = cost + E(PW of cash flows)
= –250,000 + 202,063
= $–47,937

Buy option, D1

At D2, E(PW) = $86,960

E(PW for buy) = cost + E(PW of sales cash flows)
= -450,000 + 0.55(PW sales up) + 0.45(PW sales down)

PW Sales up = 100,000(P/A,15%,2) + 86,960(P/F,15%,2)
= $228,320

PW sales down = (25,000 + 200,000)(P/F,15%,1)
= $195,660

E(PW for buy) = -450,000 + 0.55 (228,320) + 0.45(195,660)
= $–236,377

Conclusion: E(PW for produce) is larger than E(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.

18.40 In $ billion units, PW_{option} = 3 - 3.1(P/F,12%,1)
= 3 - 3.1(0.8929)
= $0.232 ($232 million)

18.41 In $ million units,

$PW_{Invest\ now}$ = -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 ($4.028 million)

$PW_{Invest\ later}$ = -4 + 0.9(P/F,12%,1) – 80(P/F,12%,1) + [35(0.5) + 25(0.5)] ×(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 ($6.732 million)

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.

18.42 PW_{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

$PW_{1\ year}$ = -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

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

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

Not considering any noneconomic factors, the warranty is worth an expected $2237, or $263 less than the option price.

(b) PW_{base} = -500(P/F,5%,3) -2000(P/F,5%,4)
= -500(0.8638) -2000(0.8227)
= $-2077

18.44 Answer is (b)

18.45 Answer is (a)

18.46 Answer is (c)

18.47 E(AW) = 30,000(0.2) + 40,000(0.2) + 50,000(0.6)
= $44,000

Answer is (c)

18.48 $AW_{Optimistic}$ = -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 (> $-48,000)

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)

18.51 PW = 70,000 – 70,000(P/F,10%,1)
= 70,000 – 70,000(0.9091)
= $6363

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	Not all years shown	
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%	

2. Sensitivity to changes in life is performed by hand. *Not very sensitive*; plan A has the best PW for all life estimates.

<u>Expanding economy</u>

n_A = 40(0.80) = 32 years
n_1 = 40(0.80) = 32 years
n_2 = 20(0.80) = 16 years

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

PW_B = –30,000 + 5000(P/F,10%,32) – 100(P/A,10%,32) – 5000
–200(P/F,10%,16) – 5000(P/F,10%,16) – 200(P/F,10%,32)
–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

Expected economy

PW_A = –10,000 + 1000(P/F,10%,40) – 500(P/A,10%,40)
= –10,000 + 1000(0.0221) – 500(9.7791)
= \$-14,867

PW_B = –30,000 + 5000(P/F,10%,40) – 100(P/A,10%,40) – 5000
– 200(P/F,10%,20) – 5000(P/F,10%,20) – 200(P/F,10%,40)
– 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

Receding economy

n_A = 40(1.10) = 44 years
n_1 = 40(1.10) = 44 years
n_2 = 20(1.10) = 22 years

PW_A = –10,000 + 1000(P/F,10%,44) – 500(P/A,10%,44)
= –10,000 + 1000(0.0154) – 500(9.8461)
= \$–14,908

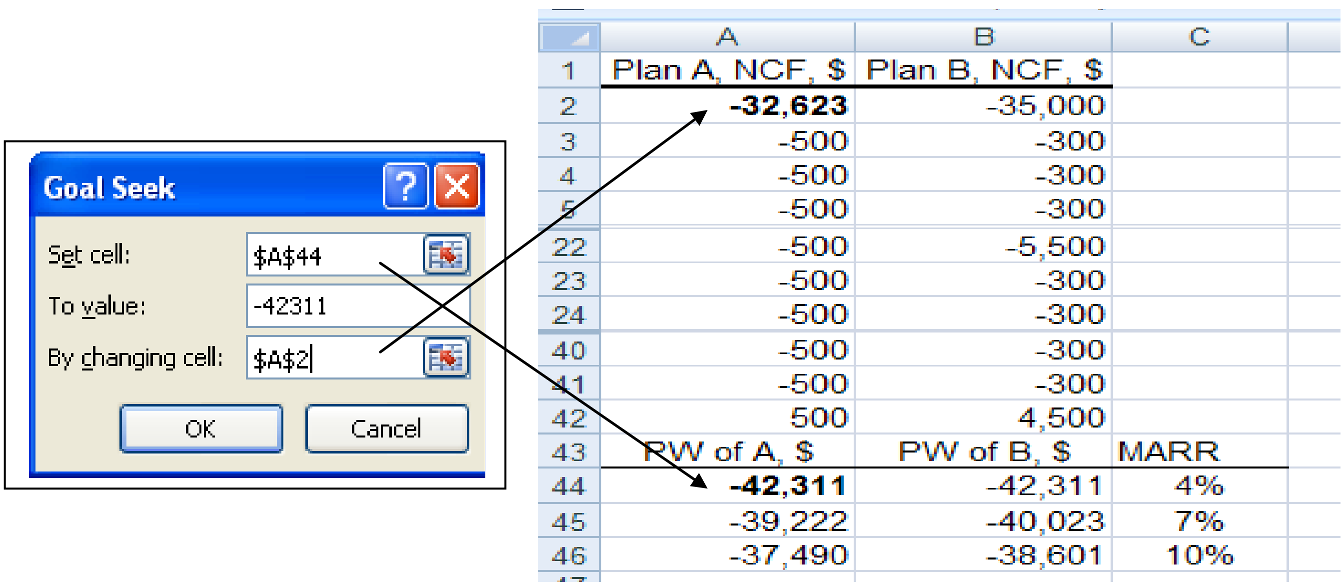
PW_B = –30,000 + 5000(P/F,10%,44) – 100(P/A,10%,44) – 5000
– 200(P/F,10%,22) – 5000(P/F,10%,22) – 200(P/F,10%,44)
– 200(P/F,10%,44)
= –35,000 + 4800(P/F,10%,44) – 300(P/A,10%,44) – 5200(P/F,10%,22)
= –35,000 + 4800(0.0154) – 300(9.8461) – 5200(0.1228)
= \$–38,519

3. 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,

$$2x + x + x + x + x + x = 100$$
$$7x = 100$$
$$x = 14.3\%$$

   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,

$$3{,}881{,}879 = P_4(A/P, 8\%, 20) + 1{,}063{,}449$$
$$3{,}881{,}879 = P_4(0.10185) + 1{,}063{,}449$$
$$P_4 = \$27{,}672{,}361$$

$$\text{Decrease} = 29{,}000{,}000 - 27{,}672{,}361$$
$$= \$1{,}327{,}639 \text{ or } 4.58\%$$

4. Household cost at 100% = 3,952,959(1/12)(1/4980)(1/1)
   = \$66.15

   Decrease = 69.63 – 66.15
   = \$3.48 or 5%

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 ≥ 12,600) = P(RI = 12,600) + P(RI =15,500)
= 0.09 + 0.04
= 0.13

19.5 (a) Frequency distribution is as follows

Cell boundaries	Frequencies
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

Cell Boundaries	Frequencies	Probability
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($ ≥ 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.

N	0	1	2	3	4
P(N)	.12	.56	.26	.03	.03
F(N)	.12	.68	.94	.97	1.00

i	0-2	2-4	4-6	6-8	8-10	10-12
P(i)	.13	.14	.19	.38	.12	.04
F(i)	.13	.27	.46	.84	.96	1.00

(c) P(N = 1or 2) = P(N = 1) + P(N = 2)
= 0.56 + 0.26 = 0.82
or
F(N ≤ 2) – F(N ≤ 0) = 0.94 – 0.12 = 0.82

P(N ≥ 3) = P(N = 3) + P(N ≥ 4) = 0.06

(d) P(7% ≤ i ≤ 11%) = P(6.01 ≤ i ≤ 12.0)
= 0.38 + 0.12 + 0.04 = 0.54
or
F(i ≤ 12%) – F(i ≤ 6%) = 1.00 – 0.46
= 0.54

19.7 (a)

$	0	2	5	10	100
F($)	.91	.955	.98	.993	1.000

The variable $ is discrete, so plot $ versus F($).

(b) $E(\$) = \sum \$P(\$) = 0.91(0) + ... + 0.007(100)$
$= 0 + 0.09 + 0.125 + 0.13 + 0.7$
$= \$1.045$

(c) 2.000 – 1.045 = $0.955

Long-term income is 95.5¢ per ticket

19.8 (a) $P(N) = (0.5)^N$ N = 1,2,3,...

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.

$$f(\text{mode}) = f(M) = \frac{2}{5-2} = \frac{2}{3}$$

$$F(\text{mode}) = F(M) = \frac{5-2}{5-2} = 1$$

(b) $P(N = 1, 2 \text{ or } 3) = F(N \leq 3) = 0.875$

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 is the probability at $2500.

There is no S_L distribution

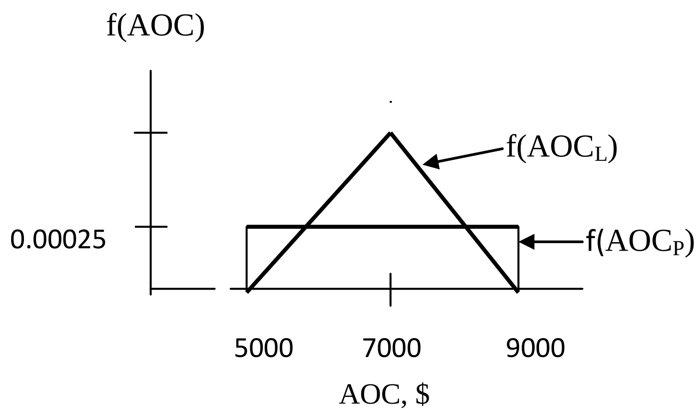
AOC

AOC_P is uniform with:

$$f(AOC_P) = 1/(9000–5000) = 0.00025$$

$f(AOC_L)$ is triangular with:

$$f(7000) = 2/(9000–5000) = 0.0005$$

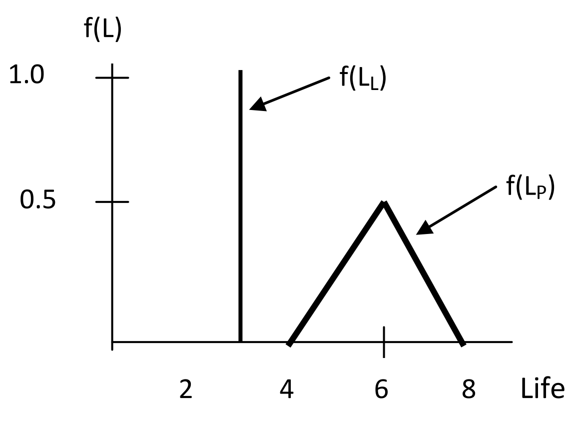


Life, L

$f(L_P)$ is triangular with mode at 6:

$$f(6) = 2/(8-4) = 0.5$$

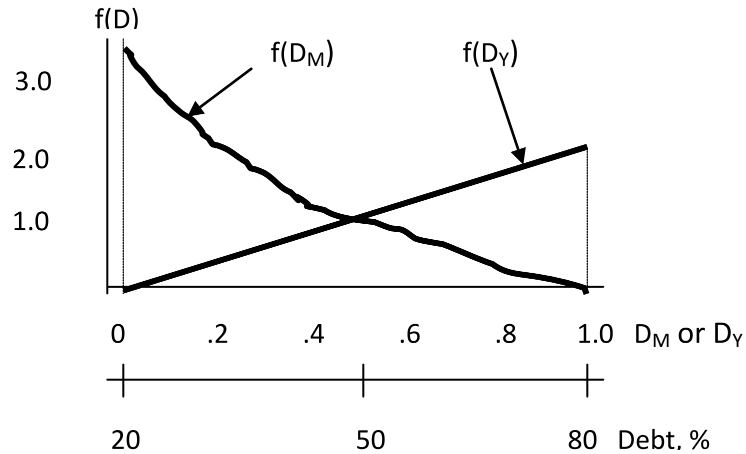
The value L_L is certain at 3 years.



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:

$$P(G = g) = \begin{cases} 0.30 & G = A \\ 0.40 & G = B \\ 0.20 & G = C \\ 0.10 & G = D \\ 0.00 & G = F \\ 0.00 & G = I \end{cases}$$

Steps 1 and 2: The F(G) and RN assignment are:

F(G = g)	G	RNs
0.30	G = A	00-29
0.70	G = B	30-69
0.90	G = C	70-89
1.00	G = D	90-99
1.00	G = F	--
1.00	G = I	--

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) $\overline{X} = (81, 86, 80, 91, 83, 83, 96, 85, 89)/9$
$= 86$

(b)

Reading	Mean, $\overline{X}$	$X_i - \overline{X}$	$(X_i - \overline{X})^2$
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
89	86	3	9
774	86	0	214

$s = \sqrt{214/(9-1)}$
$= 5.17$

(c) Range for ±1s is 86 ± 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_iX_i	$f_iX_i^2$
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	10	4,000,000	20,000	40,000,000
	100		136,000	199,600,000

Sample mean: $\overline{X} = 136{,}000/100 = 1360.00$

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) $\overline{X} \pm 2s$ is $1360.00 \pm 2(384.55) = 590.90$ and 2129.10

All values are in the ±2s range.

(c) Plot X versus f. Indicate $\overline{X}$ and the range $\overline{X} \pm 2s$ 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	1.0	5	100	500
		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.

$f(Y) = 2Y$

$E(Y) = \int_0^1 (Y)2Ydy$

$= \left[\frac{2Y^3}{3}\right]_0^1$

$= 2/3 - 0 = 2/3$

$Var(Y) = \int_0^1 (Y^2)2Ydy - [E(Y)]^2$

$= \left[\frac{2Y^4}{4}\right]_0^1 - (2/3)^2$

$= \frac{2}{4} - 0 - \frac{4}{9}$

$= 1/18 = 0.05556$

$\sigma = (0.05556)^{0.5} = 0.236$

(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.

$$P(0.195 \le Y \le 1.0) = \int_{0.195}^{1} 2Y\,dy$$

$$= Y^2 \Big|_{0.195}^{1}$$

$$= 1 - 0.038 = 0.962 \qquad (96.2\%)$$

19.20 (a) Use Equations [19.15] and [19.16]. Substitute M for D_M.

$$E(M) = \int_0^1 (M)\, 3\,(1 - M)^2 dm$$

$$= 3\int_0^1 (M - 2M^2 + M^3)dm$$

$$= 3\left[\frac{M^2}{2} - \frac{2M^3}{3} + \frac{M^4}{4}\right]_0^1$$

$$= \frac{3}{2} - 2 + \frac{3}{4} = \frac{6 - 8 + 3}{4} = \frac{1}{4} = 0.25$$

$$Var(M) = \int_0^1 (M^2)\, 3\,(1 - M)^2 dm - [E(M)]^2$$

$$= 3\int_0^1 (M^2 - 2M^3 + M^4)dm - (1/4)^2$$

$$= 3\left[\frac{M^3}{3} - \frac{M^4}{2} + \frac{M^5}{5}\right]_0^1 - 1/16$$

$$= 1 - 3/2 + 3/5 - 1/16$$
$$= (80 - 120 + 48 - 5)/80$$
$$= 3/80 = 0.0375$$

$$\sigma = (0.0375)^{0.5} = 0.1936$$

(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.

$$P(0 \le M \le 0.6372) = \int_0^{0.6372} 3(1 - M)^2\, dm$$

$$= 3 \int_0^{0.6372} (1 - 2M + M^2) dm$$

$$= 3 \left[M - M^2 + 1/3\, M^3 \right]_0^{0.6372}$$

$$= 3 \left[0.6372 - (0.6372)^2 + 1/3\, (0.6372)^3 \right]$$

$$= 0.952 \qquad (95.2\%)$$

19.21 Use Equation [19.8] where $P(N) = (0.5)^N$

E(N) = 1(.5) + 2(.25) + 3(.125) + 4(0.625) + 5(.03125) + 6(.015625) + 7(.0078125)
+ 8(.003906) + 9(.001953) + 10(.0009766) + ..
= 1.99+

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

$\text{Var}(Y) = \sum Y^2 P(Y) - [E(Y)]^2$
$= 3^2(1/3) + 7^2(1/4) + 10^2(1/3) + 12^2(1/12) - (7.083)^2$
= 60.583 - 50.169
= 10.414

$\sigma = 3.227$

$E(Y) \pm 1\sigma$ is $7.083 \pm 3.227 = 3.856$ 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.

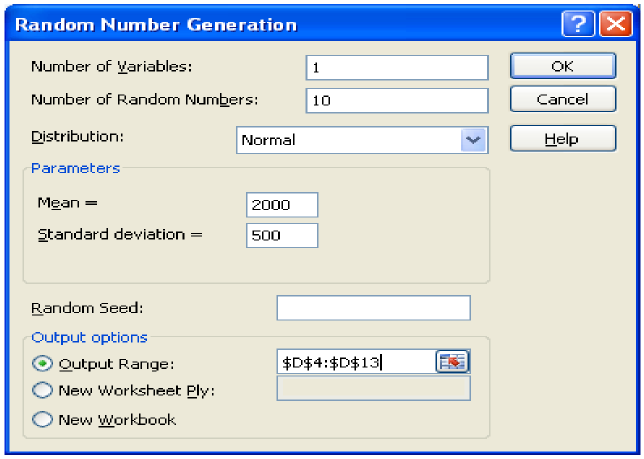
	A	B	C	D	E	F	G	H
1						Annual CFAT	Annual CFAT	Annual CFAT
2			RN for	CFAT,		using D4 for CFAT	using D5 for CFAT	using D6 for CFAT
3	RN for i	i	CFAT	years 7-10	Year	and B4 for MARR	and B5 for MARR	and B6 for MARR
4	35.5552	7.42%	13.514	$ 1,708	0	-28,800	-28,800	-28,800
5	28.6264	7.14%	39.9931	$ 1,919	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 μ = \$2000 and σ = \$500. The RNG screen image is shown below.



	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)

19.29 P($ <9600) = P($ = 6200) + P($ = 8500)
= 0.15 + 0.23
= 0.38

Answer is (d)

19.30 Answer is (c)

19.31 $s = \sqrt{1{,}600{,}000/(12 - 1)}$
= $381

Answer is (a)

19.32 Two numbers (46 and 27) are in the range 25 to 49, which indicate type B.

P(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.