ENGINEERING ECONOMY

Solucionario

Leland Blank • Anthony Tarquin

By Keyser Söze

UNIVERSIDAD AUTONOMA DEL ESTADO DE MORELOS (UAEM)
FACULTAD DE CIENCIAS QUÍMICAS E INGENIERÍA (FCQeI)
FORMULARIO DE INGENIERIA ECONOMICA

$$F = P(1+i)^n \qquad F = P(F/P,i,n)$$

$$P = F\left[\frac{1}{(1+i)^n}\right] \qquad P = F(P/F,i,n)$$

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] \qquad A = P(A/P,i,n)$$

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right] \qquad P = A(P/A,i,n)$$

$$F = A\left[\frac{(1+i)^n - 1}{i}\right] \qquad F = A(F/A,i,n)$$

$$A = F\left[\frac{i}{(1+i)^n - 1}\right] \qquad A = F(A/F,i,n)$$

$$P = G\left[\frac{1}{i}\right]\left[\frac{(1+i)^n - 1}{i} - n\right]\left[\frac{1}{(1+i)^n}\right] \qquad P = G(P/G,i,n)$$

$$F = G\left[\frac{1}{i}\right]\left[\frac{(1+i)^n - 1}{i} - n\right] \qquad F = G(F/G,i,n)$$

$$A = G\left[\frac{1}{i} - \frac{n}{(1+i)^n - 1}\right] \qquad A = G(A/G,i,n)$$

$$P = A\left[\frac{1 - \frac{(1+j)^n}{(1+i)^n}}{i - j}\right] \qquad \text{Si } i \neq j \qquad P = A(P/A,i,j,n)$$

$$P = A\left[\frac{n}{1+i}\right] \qquad \text{Si } i = j \qquad P = A(P/A,i,j,n)$$

$$F = P + Pni$$

$$I = F - P$$

$$i = \left(\frac{F - P}{P}\right) * 100$$

$$i_{\text{por periodo}} = \frac{r}{m}$$

$$i = \left[\left(1 + \frac{r}{m}\right)^m - 1\right] * 100$$

$$i = \left(e^{r(n)} - 1\right) * 100$$

$$D_t = \frac{1}{n}(P - Vs)$$

$$D = \left[\frac{n - (t-1)}{n(n+1)/2}\right](P - Vs)$$

$$i' = i + f + if$$

$$y = y_1 + (x - x_1)\left(\frac{y_2 - y_1}{x_2 - x_1}\right)$$

ING. ALFREDO PÉREZ PATIÑO

Chapter 1

Foundations of Engineering Economy

Solutions to Problems

1.1 Time value of money means that there is a certain worth in having money and the worth changes as a function of time.

1.2 Morale, goodwill, friendship, convenience, aesthetics, etc.

1.3 (a) Evaluation criterion is the measure of value that is used to identify "best".
(b) The primary evaluation criterion used in economic analysis is cost.

1.4 Nearest, tastiest, quickest, classiest, most scenic, etc

1.5 If the alternative that is actually the best one *is not even recognized as an alternative*, it obviously will not be able to be selected using *any* economic analysis tools.

1.6 In simple interest, the interest rate applies only to the principal, while compound interest generates interest on the principal *and* all accumulated interest.

1.7 Minimum attractive rate of return is the lowest rate of return (interest rate) that a company or individual considers to be high enough to induce them to invest their money.

1.8 Equity financing involves the use of the corporation's or individual's own funds for making investments, while debt financing involves the use of borrowed funds. An example of equity financing is the use of a corporation's cash or an individual's savings for making an investment. An example of debt financing is a loan (secured or unsecured) or a mortgage.

1.9 Rate of return = (45/966)(100)
= 4.65%

1.10 Rate of increase = [(29 – 22)/22](100)
= 31.8%

1.11 Interest rate = (275,000/2,000,000)(100)
= 13.75%

1.12 Rate of return = (2.3/6)(100)
= 38.3%

1.13 Profit = 8(0.28)
= \$2,240,000

1.14 P + P(0.10) = 1,600,000
1.1P = 1,600,000
P = \$1,454,545

1.15 Earnings = 50,000,000(0.35)
= \$17,500,000

1.16 (a) Equivalent future amount = 10,000 + 10,000(0.08)
= 10,000(1 + 0.08)
= \$10,800

(b) Equivalent past amount: P + 0.08P = 10,000
1.08P = 10,000
P = \$9259.26

1.17 Equivalent cost now: P + 0.1P = 16,000
1.1P = 16,000
P = \$14,545.45

1.18 40,000 + 40,000(i) = 50,000
i = 25%

1.19 80,000 + 80,000(i) = 100,000
i = 25%

1.20 F = 240,000 + 240,000(0.10)(3)
= \$312,000

1.21 Compound amount in 5 years = $1,000,000(1 + 0.07)^5$
= \$1,402,552
Simple amount in 5 years = 1,000,000 + 1,000,000(0.075)(5)
= \$1,375,000

Compound interest is better by \$27,552

1.22 Simple: 1,000,000 = 500,000 + 500,000(i)(5)
i = 20% per year simple

Compound: $1,000,000 = 500,000(1 + i)^5$
$(1 + i)^5 = 2.0000$
$(1 + i) = (2.0000)^{0.2}$
i = 14.87%

1.23 Simple: $2P = P + P(0.05)(n)$

$$P = P(0.05)(n)$$
$$n = 20 \text{ years}$$

Compound: $2P = P(1 + 0.05)^n$

$$(1 + 0.05)^n = 2.0000$$
$$n = 14.2 \text{ years}$$

1.24 (a) Simple: $1{,}300{,}000 = P + P(0.15)(10)$

$$2.5P = 1{,}300{,}000$$
$$P = \$520{,}000$$

(b) Compound: $1{,}300{,}000 = P(1 + 0.15)^{10}$

$$4.0456P = 1{,}300{,}000$$
$$P = \$321{,}340$$

1.25 Plan 1: Interest paid each year $= 400{,}000(0.10)$

$$= \$40{,}000$$

Total paid $= 40{,}000(3) + 400{,}000$

$$= \$520{,}000$$

Plan 2: Total due after 3 years $= 400{,}000(1 + 0.10)^3$

$$= \$532{,}400$$

Difference paid $= 532{,}400 – 520{,}000$

$$= \$12{,}400$$

1.26 (a) Simple interest total amount $= 1{,}750{,}000(0.075)(5)$

$$= \$656{,}250$$

Compound interest total = total amount due after 4 years – amount borrowed

$$= 1{,}750{,}000(1 + 0.08)^4 – 1{,}750{,}000$$
$$= 2{,}380856 – 1{,}750{,}000$$
$$= \$630{,}856$$

(b) The company should borrow 1 year from now for a savings of \$656,250 – \$630,856 = \$25,394

1.27 The symbols are F = ?; P = \$50,000; i = 15%; n = 3

1.28 (a) FV(i%,n,A,P) finds the future value, F
(b) IRR(first_cell:last_cell) finds the compound interest rate, i
(c) PMT(i%,n,P,F) finds the equal periodic payment, A
(d) PV(i%,n,A,F) finds the present value, P

1.29 (a) $F = ?$; $i = 7\%$; $n = 10$; $A = \$2000$; $P = \$9000$
(b) $A = ?$; $i = 11\%$; $n = 20$; $P = \$14{,}000$; $F = 0$
(c) $P = ?$; $i = 8\%$; $n = 15$; $A = \$1000$; $F = \$800$

1.30 (a) PV = P (b) PMT = A (c) NPER = n (d) IRR = i (e) FV = F

1.31 For built-in Excel 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 because it is an end function. When the function involved is an interior one (like P in the PMT function), a comma must be put in its position.

1.32 (a) Risky
(b) Safe
(c) Safe
(d) Safe
(e) Risky

1.33 (a) Equity
(b) Equity
(c) Equity
(d) Debt
(e) Debt

1.34 Highest to lowest rate of return is as follows: Credit card, bank loan to new business, corporate bond, government bond, interest on checking account

1.35 Highest to lowest interest rate is as follows: rate of return on risky investment, minimum attractive rate of return, cost of capital, rate of return on safe investment, interest on savings account, interest on checking account.

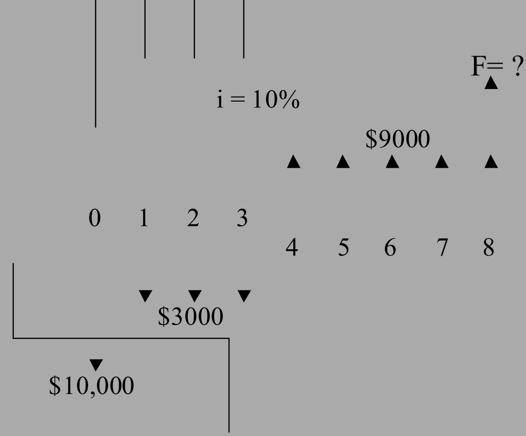
1.36 WACC = (0.25)(0.18) + (0.75)(0.10) = 12%
Therefore, MARR = 12%

Select the last three projects: 12.4%, 14%, and 19%

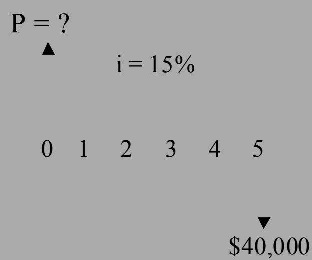
1.37 End of period convention means that the cash flows are assumed to have occurred at the end of the period in which they took place.

1.38 The following items are inflows: salvage value, sales revenues, cost reductions
The following items are outflows: income taxes, loan interest, rebates to dealers, accounting services

1.39 The cash flow diagram is:



1.40 The cash flow diagram is:



1.41 Time to double = 72/8
= 9 years

1.42 Time to double = 72/9
= 8 years

Time to quadruple = (8)(2)
= 16 years

1.43 4 = 72/i
i = 18% per year

1.44 Account must double in value five times to go from $62,500 to $2,000,000 in 20 years. Therefore, account must double every 20/5 = 4 years.

Required rate of return = 72/4
= 18% per year

FE Review Solutions

1.45 Answer is (c)

1.46 2P = P + P(0.05)(n)
n = 20
Answer is (d)

1.47 Amount now = 10,000 + 10,000(0.10)
= $11,000

Answer is (c)

1.48 i = 72/9 = 8 %

Answer is (b)

1.49 Answer is (c)

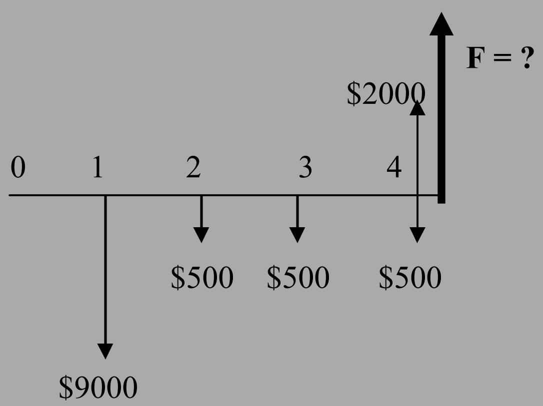
1.50 Let i = compound rate of increase:

$$235 = 160(1 + i)^5$$
$$(1 + i)^5 = 235/160$$
$$(1 + i) = (1.469)^{0.2}$$
$$(1 + i) = 1.07995$$
$$i = 7.995\% = 8.0\%$$

Answer is (c)

Extended Exercise Solution

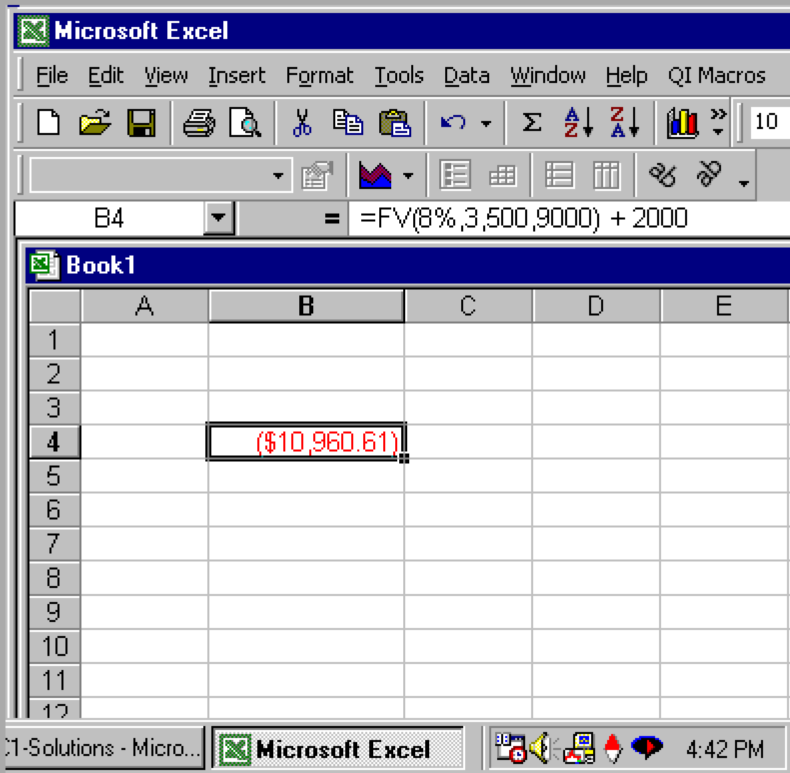
1.



F = [{[–9000(1.08) – 500] (1.08)} – 500] (1.08) + (2000–500)
= $–10,960.60

or F = –9000(F/P,8%,3) – 500(F/A,8%,3) + 2000

2. A spreadsheet uses the FV function as shown in the formula bar. F = $–10,960.61.



3. F = [{[–9000(1.08) – 300] (1.08)} – 500] (1.08) + (2000 –1000)
   = $–11,227.33

   Change is 2.02%. Largest maintenance charge is in the last year and, therefore, no compound interest is accumulated by it.

4. The fastest method is to use the spreadsheet function:

   FV(12.32%,3,500,9000) + 2000

   It displays the answer:

   F = $–12,445.43

Case Study Solution

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

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.

Chapter 2

Factors: How Time and Interest Affect Money

Solutions to Problems

2.1 1. (F/P,8%25) = 6.8485; 2. (P/A,3%,8) = 7.0197; 3. (P/G,9%,20) = 61.7770;
4. (F/A,15%,18) = 75.8364; 5. (A/P,30%,15) = 0.30598

2.2 P = 140,000(F/P,7%,4)
=140,000(1.3108)
= $183,512

2.3 F = 200,000(F/P,10%,3)
= 200,000(1.3310)
= $266,200

2.4 P = 600,000(P/F,12%,4)
= 600,000(0.6355)
= $381,300

2.5 (a) A = 225,000(A/P,15%,4)
= 225,000(0.35027)
= $78,811

(b) Recall amount = 78,811/0.10
= $788,110 per year

2.6 F = 150,000(F/P,18%,7)
= 150,000(3.1855)
= $477,825

2.7 P = 75(P/F,18%,2)
= 75(0.7182)
= $53.865 million

2.8 P = 100,000((P/F,12%,2)
= 100,000(0.7972)
= $79,720

2.9 F = 1,700,000(F/P,18%,1)
= 1,700,000(1.18)
= $2,006,000

2.10 $P = 162{,}000(P/F,12\%,6)$
$= 162{,}000(0.5066)$
$= \$82{,}069$

2.11 $P = 125{,}000(P/F,14\%,5)$
$= 125{,}000(0.5149)$
$= \$\ 64{,}925$

2.12 $P = 9000(P/F,10\%,2) + 8000(P/F,10\%,3) + 5000(P/F,10\%,5)$
$= 9000(0.8264) + 8000(0.7513) + 5000(0.6209)$
$= \$16{,}553$

2.13 $P = 1{,}250{,}000(0.10)(P/F,8\%,2) + 500{,}000(0.10)(P/F,8\%,5)$
$= 125{,}000(0.8573) + 50{,}000(0.6806)$
$= \$141{,}193$

2.14 $F = 65{,}000(F/P,4\%,5)$
$= 65{,}000(1.2167)$
$= \$79{,}086$

2.15 $P = 75{,}000(P/A,20\%,3)$
$= 75{,}000(2.1065)$
$= \$157{,}988$

2.16 $A = 1.8(A/P,12\%,6)$
$= 1.8(0.24323)$
$= \$437{,}814$

2.17 $A = 3.4(A/P,20\%,8)$
$= 3.4(0.26061)$
$= \$886{,}074$

2.18 $P = (280{,}000-90{,}000)(P/A,10\%,5)$
$= 190{,}000(3.7908)$
$= \$720{,}252$

2.19 $P = 75{,}000(P/A,15\%,5)$
$= 75{,}000(3.3522)$
$= \$251{,}415$

2.20 $F = (458-360)(20{,}000)(0.90)(F/A,8\%,5)$
$= 1{,}764{,}000(5.8666)$
$= \$10{,}348{,}682$

2.21 $P = 200{,}000((P/A,10\%,5)$
$= 200{,}000(3.7908)$
$= \$758{,}160$

2.22 $P = 2000(P/A,8\%,35)$
$= 2000(11.6546)$
$= \$23{,}309$

2.23 $A = 250{,}000(A/F,9\%,3)$
$= 250{,}000(0.30505)$
$= \$76{,}263$

2.24 $F = (100{,}000 + 125{,}000)(F/A,15\%,3)$
$= 225{,}000(3.4725)$
$= \$781{,}313$

2.25 (a) 1. Interpolate between n = 32 and n = 34:
$1/2 = x/0.0014$
$x = 0.0007$
$(P/F,18\%,33) = 0.0050 - 0.0007$
$= 0.0043$

2. Interpolate between n = 50 and n = 55:
$4/5 = x/0.0654$
$x = 0.05232$
$(A/G,12\%,54) = 8.1597 + 0.05232$
$= 8.2120$

(b) 1. $(P/F,18\%,33) = 1/(1+0.18)^{33}$
$= 0.0042$

2. $(A/G,12\%,54) = \{(1/0.12) - 54/[(1+0.12)^{54} - 1\}$
$= 8.2143$

2.26 (a) 1. Interpolate between i = 18% and i = 20% at n = 20:
$1/2 = x/40.06$
$x = 20.03$
$(F/A,19\%,20) = 146.6280 + 20.03$
$=166.658$

2. Interpolate between i = 25% and i = 30% at n = 15:
$1/5 = x/0.5911$
$x = 0.11822$
$(P/A,26\%,15) = 3.8593 - 0.11822$
$= 3.7411$

(b) 1. $(F/A,19\%,20) = [(1 + 0.19)^{20} - 0.19]/0.19$
$= 169.6811$

2. $(P/A,26\%,15) = [(1 + 0.26)^{15} - 1]/[0.26(1 + 0.26)^{15}]$
$= 3.7261$

2.27 (a) $G = \$200$ (b) $CF_8 = \$1600$ (c) $n = 10$

2.28 (a) $G = \$5$ million (b) $CF_6 = \$6030$ million (c) $n = 12$

2.29 (a) $G = \$100$ (b) $CF_5 = 900 - 100(5) = \$400$

2.30 $300{,}000 = A + 10{,}000(A/G,10\%,5)$
$300{,}000 = A + 10{,}000(1.8101)$
$A = \$281{,}899$

2.31 (a) $CF_3 = 280{,}000 - 2(50{,}000)$
$= \$180{,}000$
(b) $A = 280{,}000 - 50{,}000(A/G,12\%,5)$
$= 280{,}000 - 50{,}000(1.7746)$
$= \$191{,}270$

2.32 (a) $CF_3 = 4000 + 2(1000)$
$= \$6000$
(b) $P = 4000(P/A,10\%,5) + 1000(P/G,10\%,5)$
$= 4000(3.7908) + 1000(6.8618)$
$= \$22{,}025$

2.33 $P = 150{,}000(P/A,15\%,8) + 10{,}000(P/G,15\%,8)$
$= 150{,}000(4.4873) + 10{,}000(12.4807)$
$= \$797{,}902$

2.34 $A = 14{,}000 + 1500(A/G,12\%,5)$
$= 14{,}000 + 1500(1.7746)$
$= \$16{,}662$

2.35 (a) Cost $= 2000/0.2$
$= \$10{,}000$
(b) $A = 2000 + 250(A/G,18\%,5)$
$= 2000 + 250(1.6728)$
$= \$2418$

2.36 Convert future to present and then solve for G using P/G factor:

$$6000(P/F,15\%,4) = 2000(P/A,15\%,4) - G(P/G,15\%,4)$$
$$6000(0.5718) = 2000(2.8550) - G(3.7864)$$
$$G = \$601.94$$

2.37 $50 = 6(P/A,12\%,6) + G(P/G,12\%,6)$

$50 = 6(4.1114) + G(8.9302)$

$G = \$2,836,622$

2.38 $A = [4 + 0.5(A/G,16\%,5)] - [1 - 0.1(A/G,16\%,5)$

$= [4 + 0.5(1.7060)] - [1 - 0.1(1.7060)]$

$= \$4,023,600$

2.39 For n = 1: $\{1 - [(1+0.04)^1/(1+0.10)^1\}]\}/(0.10 - 0.04) = 0.9091$

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

For n = 3: $\{1 - [(1+0.04)^3/(1+0.10)^3\}]\}/(0.10 - 0.04) = 2.5812$

2.40 For g = i, $P = 60,000(0.1)[15/(1 + 0.04)]$

$= \$86,538$

2.41 $P = 25,000\{1 - [(1+0.06)^3/(1+0.15)^3\}]\}/(0.15 - 0.06)$

$= \$60,247$

2.42 Find P and then convert to A.

$P = 5,000,000(0.01)\{1 - [(1+0.20)^5/(1+0.10)^5\}]\}/(0.10 - 0.20)$

$= 50,000\{5.4505\}$

$= \$272,525$

$A = 272,525(A/P,10\%,5)$

$= 272,525(0.26380)$

$= \$71,892$

2.43 Find P and then convert to F.

$P = 2000\{1 - [(1+0.10)^7/(1+0.15)^7\}]\}/(0.15 - 0.10)$

$= 2000(5.3481)$

$= \$10,696$

$F = 10,696(F/P,15\%,7)$

$= 10,696(2.6600)$

$= \$28,452$

2.44 First convert future worth to P, then use P_g equation to find A.

$P = 80,000(P/F,15\%,10)$

$= 80,000(0.2472)$

$= \$19,776$

$19{,}776 = A\{1 - [(1+0.09)^{10}/(1+0.15)^{10}\}]\}/(0.15 - 0.09)$
$19{,}776 = A\{6.9137\}$
$A = \$2860$

2.45 Find A in year 1 and then find next value.
$900{,}000 = A\{1 - [(1+0.05)^{5}/(1+0.15)^{5}\}]\}/(0.15 - 0.05)$
$900{,}000 = A\{3.6546)$
$A = \$246{,}263$ in year 1
Cost in year 2 = 246,263(1.05)
= \$258,576

2.46 g = i: P = 1000[20/(1 + 0.10)]
= 1000[18.1818]
= \$18,182

2.47 Find P and then convert to F.
$P = 3000\{1 - [(1+0.05)^{4}/(1+0.08)^{4}\}]\}/(0.08 - 0.05)$
= 3000{3.5522}
= \$10,657

F = 10,657(F/P,8%,4)
= 10,657(1.3605)
= \$14,498

2.48 Decrease deposit in year 4 by 5% per year for three years to get back to year 1.
First deposit = $1250/(1 + 0.05)^{3}$
= \$1079.80

2.49 Simple: Total interest = (0.12)(15) = 180%
Compound: $1.8 = (1 + i)^{15}$
i = 4.0%

2.50 Profit/year = 6(3000)/0.05 = \$360,000
1,200,000 = 360,000(P/A,i,10)
(P/A,i,10) = 3.3333
i = 27.3% (Excel)

2.51 2,400,000 = 760,000(P/A,i,5)
(P/A,i,5) = 3.15789
i = 17.6% (Excel)

2.52 1,000,000 = 600,000(F/P,i,5)
(F/P,i,5) = 1.6667
i = 10.8% (Excel)

2.53 $125{,}000 = (520{,}000 - 470{,}000)(P/A,i,4)$
$(P/A,i,4) = 2.5000$
$i = 21.9\%$ (Excel)

2.54 $400{,}000 = 320{,}000 + 50{,}000(A/G,i,5)$
$(A/G,i,5) = 1.6000$
Interpolate between i = 22% and i = 24%
$i = 22.6\%$

2.55 $85{,}000 = 30{,}000(P/A,i,5) + 8{,}000(P/G,i,5)$
Solve for i by trial and error or spreadsheet:
$i = 38.9\%$ (Excel)

2.56 $500{,}000 = 75{,}000(P/A,10\%,n)$
$(P/A,10\%,n) = 6.6667$

From 10% table, n is between 11 and 12 years; therefore, n = 11 years

2.57 $160{,}000 = 30{,}000(P/A,12\%,n)$
$(P/A,12\%,n) = 5.3333$

From 12% table, n is between 9 and 10 years; therefore, n = 10 years

2.58 $2{,}000{,}000 = 100{,}000(P/A,4\%,n)$
$(P/A,4\%,n) = 20.000$

From 4% table, n is between 40 and 45 years; by spreadsheet, $42 > n > 41$
Therefore, n = 41 years

2.59 $1{,}500{,}000 = 3{,}000{,}000(P/F,20\%,n)$
$(P/F,20\%,n) = 0.5000$

From 20% table, n is between 3 and 4 years; therefore, n = 4 years

2.60 $100{,}000 = 1{,}600{,}000(P/F,18\%,n)$
$(P/F,18\%,n) = 0.0625$

From 18% table, n is between 16 and 17 years; therefore, n = 17 years

2.61 $10A = A(F/A,10\%,n)$
$(F/A,10\%,n) = 10.000$

From 10% table, n is between 7 and 8 years; therefore, n = 8 years

2.62 $1{,}000{,}000 = 10{,}000\{1 - [(1+0.10)^n/(1+0.07)^n\}]\}/(0.07 - 0.10)$

By trial and error, n = is between 50 and 51; therefore, n = 51 years

2.63 $12{,}000 = 3000 + 2000(A/G,10\%,n)$

$(A/G,10\%,n) = 4.5000$

From 10% table, n is between 12 and 13 years; therefore, n = 13 years

FE Review Solutions

2.64 $P = 61{,}000(P/F,6\%,4)$

$= 61{,}000(0.7921)$

$= \$48{,}318$

Answer is (c)

2.65 $160 = 235(P/F,i,5)$

$(P/F,i,5) = 0.6809$

From tables, i = 8%

Answer is (c)

2.66 $23{,}632 = 3000\{1 - [(1+0.04)^n/(1+0.06)^n]\}/(0.06-0.04)$

$[(23{,}632*0.02)/3000]-1 = (0.98113)^n$

$\log 0.84245 = n\log 0.98113$

$n = 9$

Answer is (b)

2.67 $109.355 = 7(P/A,i,25)$

$(P/A,i,25) = 15.6221$

From tables, i = 4%

Answer is (a)

2.68 $A = 2{,}800{,}000(A/F,6\%,10)$

$= \$212{,}436$

Answer is (d)

2.69 $A = 10{,}000{,}000((A/P,15\%,7)$

$= \$2{,}403{,}600$

Answer is (a)

2.70 $P = 8000(P/A,10\%,10) + 500(P/G,10\%,10)$

$= 8000(6.1446) + 500(22.8913)$

$= \$60{,}602.45$

Answer is (a)

2.71 $F = 50{,}000(F/P,18\%,7)$
$= 50{,}000(3.1855)$
$= \$159{,}275$
Answer is (b)

2.72 $P = 10{,}000(P/F,10\%,20)$
$= 10{,}000(0.1486)$
$= \$1486$
Answer is (d)

2.73 $F = 100{,}000(F/A,18\%,5)$
$= 100{,}000(7.1542)$
$= \$715{,}420$
Answer is (c)

2.74 $P = 100{,}000(P/A,10\%,5) - 5000(P/G,10\%,5)$
$= 100{,}000(3.7908) - 5000(6.8618)$
$= \$344{,}771$
Answer is (a)

2.75 $F = 20{,}000(F/P,12\%,10)$
$= 20{,}000(3.1058)$
$= \$62{,}116$
Answer is (a)

2.76 $A = 100{,}000(A/P,12\%,5)$
$= 100{,}000(0.27741)$
$= \$27{,}741$
Answer is (b)

2.77 $A = 100{,}000(A/F,12\%,3)$
$= 100{,}000(0.29635)$
$= \$29{,}635$
Answer is (c)

2.78 $A = 10{,}000(F/A,12\%,25)$
$= 10{,}000(133.3339)$
$= \$1{,}333{,}339$
Answer is (d)

2.79 $F = 10{,}000(F/P,12\%,5) + 10{,}000(F/P,12\%,3) + 10{,}000$
$= 10{,}000(1.7623) + 10{,}000(1.4049) + 10{,}000$
$= \$41{,}672$
Answer is (c)

2.80 $P = 8{,}000(P/A,10\%,5) + 900(P/G,10\%,5)$

$= 8{,}000(3.7908) + 900(6.8618)$

$= \$36{,}502$

Answer is (d)

2.81 $100{,}000 = 20{,}000(P/A,i,10)$

$(P/A,i,10) = 5.000$

i is between 15 and 16%

Answer is (a)

2.82 $60{,}000 = 15{,}000(P/A,18\%,n)$

$(P/A,18\%,n) = 4.000$

n is between 7 and 8

Answer is (b)

Case Study Solution

I. <u>Manhattan Island</u>

Simple interest

n = 375 years from 1626 – 2001

$P + I = P + nPi = 375(24)(.06) + 24$

$= P(1 + ni) = 24(1 + 375(.06))$

$= \$564$

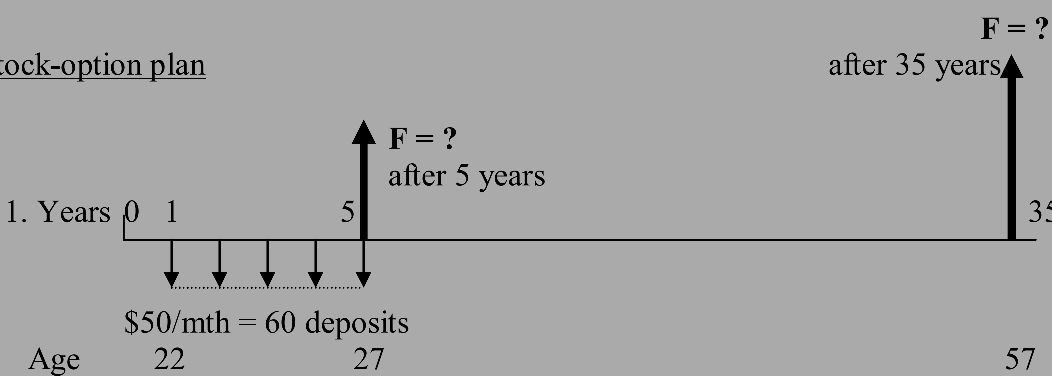
Compound interest

$F = P(F/P,6\%,375)$

$= 24(3{,}088{,}157{,}729.0)$

$= \$74{,}115{,}785{,}490$, which is \$74+ billion

II. <u>Stock-option plan</u>



2. Value when leaving the company

$$F = A(F/A,1.25\%,60)$$
$$= 50(88.5745)$$
$$= \$4428.73$$

3. Value at age 57 (n = 30 years)

$$F = P(F/P,15\%,30)$$
$$= 4428.73(66.2118)$$
$$= \$293,234$$

4. Amount for 7 years to accumulate F = $293,234

$$A = F(A/F,15\%,7)$$
$$= 293,234(.09036)$$
$$= \$26,497 \text{ per year}$$

5. Amount in 20's: 5(12)50 = $3000
Amount in 50's: 7(26,497) = $185,479

Chapter 3
Combining Factors

Solutions to Problems

3.1 P = 100,000(260)(P/A,10%,8)(P/F,10%,2)
= 26,000,000(5.3349)(0.8264)
= $114.628 million

3.2 P = 50,000(56)(P/A,8%,4)(P/F,8%,1)
= 2,800,000(3.3121)(0.9259)
= $8.587 million

3.3 P = 80(2000)(P/A,18%,3) + 100(2500)(P/A,18%,5)(P/F,18%,3)
= 160,000(2.1743) + 250,000(3.1272)(0.6086)
= $823,691

3.4 P = 100,000(P/A,15%,3) + 200,000(P/A,15%,2)(P/F,15%,3)
= 100,000(2.2832) + 200,000(1.6257)(0.6575)
= $442,100

3.5 P = 150,000 + 150,000(P/A,10%,5)
= 150,000 + 150,000(3.7908)
= $718,620

3.6 P = 3500(P/A,10%,3) + 5000(P/A,10%,7)(P/F,10%,3)
= 3500(2.4869) + 5000(4.8684)(0.7513)
= $26,992

3.7 A = [0.701(5.4)(P/A,20%,2) + 0.701(6.1)(P/A,20%,2)((P/F,20%,2)](A/P,20%,4)
= [3.7854(1.5278) + 4.2761(1.5278)(0.6944)](0.38629)
= $3.986 billion

3.8 A = 4000 + 1000(F/A,10%,4)(A/F,10%,7)
= 4000 + 1000(4.6410)(0.10541)
= $4489.21

3.9 A = 20,000(P/A,8%,4)(A/F,8%,14)
= 20,000(3.3121)(0.04130)
= $2735.79

3.10 A = 8000(A/P,10%,10) + 600
= 8000(0.16275) + 600
= $1902

3.11 $A = 20{,}000(F/P,8\%,1)(A/P,8\%,8)$
$= 20{,}000(1.08)(0.17401)$
$= \$3758.62$

3.12 $A = 10{,}000(F/A,8\%,26)(A/P,8\%,30)$
$= 10{,}000(79.9544)(0.08883)$
$= \$71{,}023$

3.13 $A = 15{,}000(F/A,8\%,9)(A/F,8\%,10)$
$= 15{,}000(12.4876)(0.06903)$
$= \$12{,}930$

3.14 $A = 80{,}000(A/P,10\%,5) + 80{,}000$
$= 80{,}000(0.26380) + 80{,}000$
$= \$101{,}104$

3.15 $A = 5000(A/P,6\%,5) + 1{,}000{,}000(0.15)(0.75)$
$= 5000(0.2374) + 112{,}500$
$= \$113{,}687$

3.16 $A = [20{,}000(F/A,8\%,11) + 8000(F/A,8\%,7)](A/F,8\%,10)$
$= [20{,}000(16.6455) + 8000(8.9228)]\{0.06903)$
$= \$27{,}908$

3.17 $A = 600(A/P,12\%,5) + 4000(P/A,12\%,4)(A/P,12\%,5)$
$= 600(0.27741) + 4000(3.0373)(0.27741)$
$= \$3536.76$

3.18 $F = 10{,}000(F/A,15\%,21)$
$= 10{,}000(118.8101)$
$= \$1{,}188{,}101$

3.19 $100{,}000 = A(F/A,7\%,5)(F/P,7\%,10)$
$100{,}000 = A(5.7507)(1.9672)$
$A = \$8839.56$

3.20 $F = 9000(F/P,8\%,11) + 600(F/A,8\%,11) + 100(F/A,8\%,5)$
$= 9000(2.3316) + 600(16.6455) + 100(5.8666)$
$= \$31{,}558$

3.21 Worth in year 5 $= -9000(F/P,12\%,5) + 3000(P/A,12\%,9)$
$= -9000(1.7623) + 3000(5.3282)$
$= \$123.90$

3.22 Amt, year 5 = 1000(F/A,12%,4)(F/P,12%,2) + 2000(P/A,12%,7)(P/F,12%,1)
= 1000(4.7793)(1.2544) + 2000(4.5638)(0.8929)
= $14,145

3.23 A = [10,000(F/P,12%,3) + 25,000](A/P,12%,7)
= [10,000(1.4049) + 25,000](0.21912)
= $8556.42

3.24 Cost of the ranch is P = 500(3000) = $1,500,000.
1,500,000 = x + 2x(P/F,8%,3)
1,500,000 = x + 2x(0.7938)
x = $579,688

3.25 Move unknown deposits to year –1, amortize using A/P, and set equal to $10,000.
x(F/A,10%,2)(F/P,10%,19)(A/P,10%,15) = 10,000
x(2.1000)(6.1159)(0.13147) = 10,000
x = $5922.34

3.26 350,000(P/F,15%,3) = 20,000(F/A,15%,5) + x
350,000(0.6575) = 20,000(6.7424) + x
x = $95,277

3.27 Move all cash flows to year 9.
0 = -800(F/A,14%,2)(F/P,14%,8) + 700(F/P,14%,7) + 700(F/P,14%,4)
–950(F/A,14%,2)(F/P,14%,1) + x – 800(P/A,14%,3)
0 = -800(2.14)2.8526) + 700(2.5023) + 700(1.6890)
–950(2.14)(1.14) + x – 800(2.3216)
x = $6124.64

3.28 Find P at t = 0 and then convert to A.
P = 5000 + 5000(P/A,12%,3) + 3000(P/A,12%,3)(P/F,12%,3)
+ 1000(P/A,12%,2)(P/F,12%,6)
= 5000 + 5000(2.4018) + 3000(2.4018)(0.7118)
+ 1000(1.6901)(0.5066)
= $22,994

A = 22,994(A/P,12%,8)
= 22,994(0.20130)
= $4628.69

3.29 F = 2500(F/A,12%,8)(F/P,12%,1) – 1000(F/A,12%,3)(F/P,12%,2)
= 2500(12.2997)(1.12) – 1000(3.3744)(1.2544)
= $30,206

3.30 $15{,}000 = 2000 + 2000(P/A,15\%,3) + 1000(P/A,15\%,3)(P/F,15\%,3) + x(P/F,15\%,7)$
$15{,}000 = 2000 + 2000(2.2832) + 1000(2.2832)(0.6575) + x(0.3759)$
$x = \$18{,}442$

3.31 Amt, year 3 $= 900(F/A,16\%,4) + 3000(P/A,16\%,2) - 1500(P/F,16\%,3)$
$+ 500(P/A,16\%,2)(P/F,16\%,3)$
$= 900(5.0665) + 3000(1.6052) - 1500(0.6407)$
$+ 500(1.6052)(0.6407)$
$= \$8928.63$

3.32 $A = 5000(A/P,12\%,7) + 3500 + 1500(F/A,12\%,4)(A/F,12\%,7)$
$= 5000(0.21912) + 3500 + 1500(4.7793)(0.09912)$
$= \$5306.19$

3.33 $20{,}000 = 2000(F/A,15\%,2)(F/P,15\%,7) + x(F/A,15\%,7) + 1000(P/A,15\%,3)$
$20{,}000 = 2000(2.1500)(2.6600) + x(11.0668) + 1000(2.2832)$
$x = \$567.35$

3.34 $P = [4{,}100{,}000(P/A,6\%,22) - 50{,}000(P/G,6\%,22)](P/F,6\%,3)$
$+ 4{,}100{,}000(P/A,6\%,3)$
$= [4{,}100{,}000(12.0416) - 50{,}000(98.9412](0.8396)$
$+ 4{,}100{,}000(2.6730)$
$= \$48{,}257{,}271$

3.35 $P = [2{,}800{,}000(P/A,12\%,7) + 100{,}000(P/G,12\%,7) + 2{,}800{,}000](P/F,12\%,1)$
$= [2{,}800{,}000(4.5638) + 100{,}000(11.6443) + 2{,}800{,}000](0.8929)$
$= \$14{,}949{,}887$

3.36 P for maintenance $= [11{,}500(F/A,10\%,2) + 11{,}500(P/A,10\%,8)$
$+ 1000(P/G,10\%,8)](P/F,10\%,2)$
$= [11{,}500(2.10) + 11{,}500(5.3349) + 1000(16.0287)](0.8264)$
$= \$83{,}904$
P for accidents $= 250{,}000(P/A,10\%,10)$
$= 250{,}000(6.1446)$
$= \$1{,}536{,}150$
Total savings $= 83{,}904 + 1{,}536{,}150$
$= \$1{,}620{,}054$
Build overpass

3.37 Find P at $t = 0$, then convert to A.
$P = [22{,}000(P/A,12\%,4) + 1000(P/G,12\%,4) + 22{,}000](P/F,12\%,1)$
$= [22{,}000(3.0373) + 1000(4.1273) + 22{,}000](0.8929)$
$= \$82{,}993$

$$
\begin{aligned}
A &= 82{,}993(A/P,12\%,5) \\
&= 82{,}993(0.27741) \\
&= \$23{,}023
\end{aligned}
$$

3.38 First find P and then convert to F.

$$
\begin{aligned}
P &= -10{,}000 + [4000 + 3000(P/A,10\%,6) + 1000(P/G,10\%,6) \\
&\qquad - 7000(P/F,10\%,4)](P/F,10\%,1) \\
&= -10{,}000 + [4000 + 3000(4.3553) + 1000(9.6842) \\
&\qquad - 7000(0.6830)](0.9091) \\
&= \$9972
\end{aligned}
$$

$$
\begin{aligned}
F &= 9972(F/P,10\%,7) \\
&= 9972(1.9487) \\
&= \$19{,}432
\end{aligned}
$$

3.39 Find P in year 0 and then convert to A.

$$
\begin{aligned}
P &= 4000 + 4000(P/A,15\%,3) - 1000(P/G,15\%,3) + [(6000(P/A,15\%,4) \\
&\qquad +2000(P/G,15\%,4)](P/F,15\%,3) \\
&= 4000 + 4000(2.2832) - 1000(2.0712) + [(6000(2.8550) \\
&\qquad +2000(3.7864)](0.6575) \\
&= \$27{,}303.69
\end{aligned}
$$

$$
\begin{aligned}
A &= 27{,}303.69(A/P,15\%,7) \\
&= 27{,}303.69(0.24036) \\
&= \$6563
\end{aligned}
$$

3.40 $40{,}000 = x(P/A,10\%,2) + (x + 2000)(P/A,10\%,3)(P/F,10\%,2)$

$40{,}000 = x(1.7355) + (x + 2000)(2.4869)(0.8264)$

$3.79067x = 35{,}889.65$

$x = \$9467.89$ (size of first two payments)

3.41 $11{,}000 = 200 + 300(P/A,12\%,9) + 100(P/G,12\%,9) - 500(P/F,12\%,3) + x(P/F,12\%,3)$

$11{,}000 = 200 + 300(5.3282) + 100(17.3563) - 500(0.7118) + x(0.7118)$

$x = \$10{,}989$

3.42 (a) In billions

$$
\begin{aligned}
P \text{ in yr } 1 &= -13(2.73) + 5.3\{[1 - (1 + 0.09)^{10}/ (1 + 0.15)^{10}]/(0.15 - 0.09)\} \\
&= -35.49 + 5.3(6.914) \\
&= \$1.1542 \text{ billion}
\end{aligned}
$$

$$
\begin{aligned}
P \text{ in yr } 0 &= 1.1542(P/F,15\%,1) \\
&= 1.1542(0.8696) \\
&= \$1.004 \text{ billion}
\end{aligned}
$$

3.43 Find P in year –1; then find A in years 0-5.

P_g in yr 2 = (5)(4000){[1 - (1 + 0.08)^{18}/(1 + 0.10)^{18}]/(0.10 - 0.08)}
= 20,000(14.0640)
= \$281,280

P in yr –1 = 281,280(P/F,10%,3) + 20,000(P/A,10%,3)
= 281,280(0.7513) + 20,000(2.4869)
= \$261,064

A = 261,064(A/P,10%,6)
= 261,064(0.22961)
= \$59,943

3.44 Find P in year –1 and then move forward 1 year

P_{-1}= 20,000{[1 – (1 + 0.05)^{11}/(1 + 0.14)^{11}]/(0.14 – 0.05)}.
= 20,000(6.6145)
= \$132,290

P = 132,290(F/P,14%,1)
= 132,290(1.14)
= \$150,811

3.45 P = 29,000 + 13,000(P/A,10%,3) + 13,000[7/(1 + 0.10)](P/F,10%,3)
= 29,000 + 13,000(2.4869) + 82,727(0.7513)
= \$123,483

3.46 Find P in year –1 and then move to year 0.

P (yr –1) = 15,000{[1 – (1 + 0.10)^5/(1 + 0.16)^5]/(0.16 – 0.10)}
= 15,000(3.8869)
= \$58,304

P = 58,304(F/P,16%,1)
= 58,304(1.16)
= \$67,632

3.47 Find P in year –1 and then move to year 5.

P (yr –1) = 210,000[6/(1 + 0.08)]
= 210,000(0.92593)
= \$1,166,667

F = 1,166,667(F/P,8%,6)
= 1,166,667(1.5869)
= \$1,851,383

3.48 $P = [2000(P/A,12\%,6) – 200(P/G,12\%,6)](F/P,12\%,1)$
$= [2000(4.1114) – 200(8.9302](1.12)$
$= \$7209.17$

3.49 $P = 5000 + 1000(P/A,12\%,4) + [1000(P/A,12\%,7) – 100(P/G,12\%,7)](P/F,12\%,4)$
$= 5000 + 1000(3.0373) + [1000(4.5638) – 100(11.6443)](0.6355)$
$= \$10,198$

3.50 Find P in year 0 and then convert to A.
$P = 2000 + 2000(P/A,10\%,4) + [2500(P/A,10\%,6) – 100(P/G,10\%,6)](P/F,10\%,4)$
$= 2000 + 2000(3.1699) + [2500(4.3553) – 100(9.6842)](0.6830)$
$= \$15,115$

$A = 15,115(A/P,10\%,10)$
$= 15,115(0.16275)$
$= \$2459.97$

3.51 $20,000 = 5000 + 4500(P/A,8\%,n) – 500(P/G,8\%,n)$
Solve for n by trial and error:
Try n = 5: $15,000 > $14,281
Try n = 6: $15,000 < $15,541
By interpolation, n = 5.6 years

3.52 $P = 2000 + 1800(P/A,15\%,5) – 200(P/G,15\%,5)$
$= 2000 + 1800(3.3522) – 200(5.7751)$
$= \$6878.94$

3.53 $F = [5000(P/A,10\%,6) – 200(P/G,10\%,6)](F/P,10\%,6)$
$= [5000(4.3553) – 200(9.6842)](1.7716)$
$= \$35,148$

FE Review Solutions

3.54 $x = 4000(P/A,10\%,5)(P/F,10\%,1)$
$= 4000(3.7908)(0.9091)$
$= \$13,785$
Answer is (d)

3.55 $P = 7 + 7(P/A,4\%,25)$
$= \$116.3547$ million
Answer is (c)

3.56 Answer is (d)

3.57 Size of first deposit = $1250/(1 + 0.05)^3$

$= \$1079.80$

Answer is (d)

3.58 Balance = 10,000(F/P,10%,2) – 3000(F/A,10%,2)

= 10,000(1.21) – 3000(2.10)

= \$5800

Answer is (b)

3.59 1000 = A(F/A,10%,5)(A/P,10%,20)

1000 = A(6.1051)(0.11746)

A = \$1394.50

Answer is (a)

3.60 First find P and then convert to A.

P = 1000(P/A,10%,5) + 2000(P/A,10%,5)(P/F,10%,5)

= 1000(3.7908) + 2000(3.7908)(0.6209)

= \$8498.22

A = 8498.22(A/P,10%,10)

= 8498.22(0.16275)

= \$1383.08

Answer is (c)

3.61 100,000 = A(F/A,10%,4)(F/P,10%,1)

100,000 = A(4.6410)(1.10)

A = \$19,588

Answer is (a)

3.62 F = [1000 + 1500(P/A,10%,10) + 500(P/G,10%,10](F/P,10%,10)

= [1000 + 1500(6.1446) + 500(22.8913](2.5937)

= \$56,186

Answer is (d)

3.63 F = 5000(F/P,10%,10) + 7000(F/P,10%,8) + 2000(F/A,10%,5)

= 5000(2.5937) + 7000(2.1438) + 2000(6.1051)

= \$40,185

Answer is (b)

Extended Exercise Solution

Solution by Hand

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 in the solution 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 for all project funds (in \$ million)

   $P = 4 + 3(P/F,7\%,1) + \ldots + 0.750(P/F,7\%,6)$
   $= 13.1716$ (\$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)

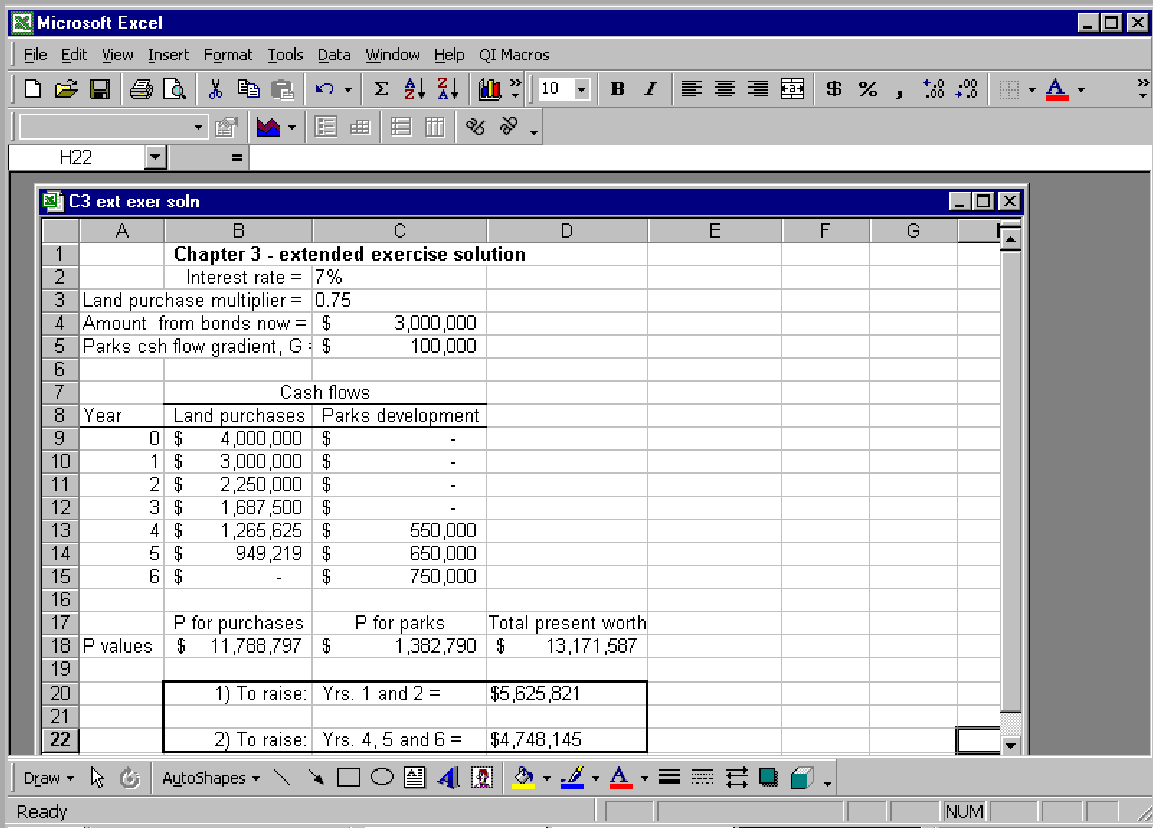
2. Find remaining project fund needs in year 3, then find the A for the next 3 years (years 4, 5, and 6):

   $F_3 = (13.1716 - 3.0)(F/P,7\%,3)$
   $= (10.1716)(1.2250)$
   $= 12.46019$

   $A = 12.46019(A/P,7\%,3)$
   $= 12.46019(0.38105)$
   $= 4.748$ (\$4,748,000 per year)

Extended Exercise Solution

Solution by computer



	A	B	C	D
1		Chapter 3 - extended exercise solution		
2		Interest rate =	7%	
3	Land purchase multiplier =		0.75	
4	Amount from bonds now =		$ 3,000,000	
5	Parks csh flow gradient, G =		$ 100,000	
6				
7		Cash flows		
8	Year	Land purchases	Parks development	
9	0	$ 4,000,000	$ -	
10	1	$ 3,000,000	$ -	
11	2	$ 2,250,000	$ -	
12	3	$ 1,687,500	$ -	
13	4	$ 1,265,625	$ 550,000	
14	5	$ 949,219	$ 650,000	
15	6	$ -	$ 750,000	
16				
17		P for purchases	P for parks	Total present worth
18	P values	$ 11,788,797	$ 1,382,790	$ 13,171,587
19				
20		1) To raise:	Yrs. 1 and 2 =	$5,625,821
21				
22		2) To raise:	Yrs. 4, 5 and 6 =	$4,748,145

Chapter 4

Nominal and Effective Interest Rates

Solutions to Problems

4.1 (a) monthly (b) quarterly (c) semiannually

4.2 (a) quarterly (b) monthly (c) weekly

4.3 (a) 12 (b) 4 (c) 2

4.4 (a) 1 (b) 4 (c) 12

4.5 (a) r/semi = 0.5*2 = 1% (b) 2% (c) 4%

4.6 (a) i = 0.12/6 = 2% per two months; r/4 months = 0.02*2 = 4%
(b) r/6 months = 0.02*3 = 6%
(c) r/2 yrs = 0.02*12 = 24%

4.7 (a) 5% (b) 20%

4.8 (a) effective (b) effective (c) nominal (d) effective (e) nominal

4.9 i/6months = 0.14/2 = 7%

4.10 $i = (1 + 0.04)^4 – 1$
$= 16.99\%$

4.11 $0.16 = (1 + r/2)^2 –1$
$r = 15.41\%$

4.12 Interest rate is stated as effective. Therefore, i = 18%

4.13 $0.1881 = (1 + 0.18/m)^m – 1$
Solve for m by trial and gives m = 2

4.14 $i = (1 + 0.01)^2 –1$
$i = 2.01\%$

4.15 $i = 0.12/12 = 1\%$ per month
Nominal per 6 months = 0.01(6) = 6%
Effective per 6 months = $(1 + 0.06/6)^6 - 1$
= 6.15%

4.16 (a) i/week = 0.068/26 = 0.262%
(b) effective

4.17 PP = weekly; CP = quarterly

4.18 PP = daily; CP = quarterly

4.19 From 2% table at n =12, F/P = 1.2682

4.20 Interest rate is effective
From 6% table at n = 5, P/G = 7.9345

4.21 P = 85(P/F,2%,12) = 85(0.7885)
= $67.02 million

4.22 F = 2.7(F/P,3%,60)
= 2.7(5.8916)
= $15.91 billion

4.23 P = 5000(P/F,4%,16)
= 5000(0.5339)
= $2669.50

4.24 P = 1.2(P/F,5%,1) (in $million)
= 1.2(0.9524)
= $1,142,880

4.25 P = 1.3(P/A,1%,28)(P/F,1%,2) (in $million)
= 1.3(24.3164)(0.9803)
= $30,988,577

4.26 F = 3.9(F/P,0.5%,120) (in $billion)
= 3.9(1.8194)
= $7,095,660,000

4.27 P = 3000(250 – 150)(P/A,4%,8) (in $million)
= 3000(100)(6.7327)
= $2,019,810

4.28 $F = 50(20,000,000)(F/P,1.5\%,9)$
$= 1,000,000,000(1.1434)$
$= \$1.1434$ billion

4.29 $A = 3.5(A/P,5\%,12)$ (in \$million)
$= 3.5(0.11283)$
$= \$394,905$

4.30 $F = 10,000(F/P,4\%,4) + 25,000(F/P,4\%,2) + 30,000(F/P,4\%,1)$
$= 10,000(1.1699) + 25,000(1.0816) + 30,000(1.04)$
$= \$69,939$

4.31 i/wk = 0.25%
$P = 2.99(P/A,0.25\%,40)$
$= 2.99(38.0199)$
$= \$113.68$

4.32 i/6 mths $= (1 + 0.03)^2 – 1$
$A = 20,000(A/P,6.09\%,4)$
$= 20,000\ \{[0.0609(1 + 0.0609)^4]/[(1 + 0.0609)^4-1]\}$
$= 20,000(0.28919)$
$= \$5784$

4.33 $F = 100,000(F/A,0.25\%,8)(F/P,0.25\%,3)$
$= 100,000(8.0704)(1.0075)$
$= \$813,093$

Subsidy = 813,093 – 800,000 = \$13,093

4.34 $P = (14.99 – 6.99)(P/A,1\%,24)$
$= 8(21.2434)$
$= \$169.95$

4.35 First find P, then convert to A

$P = 150,000\{1 – [(1+0.20)^{10}/(1+0.07)^{10}\}]\}/(0.07 – 0.20)$
$= 150,000(16.5197)$
$= \$2,477,955$

$A = 2,477,955(A/P,7\%,10)$
$= 2,477,955(0.14238)$
$= \$352,811$

4.36 $P = 80(P/A,3\%,12) + 2(P/G,3\%,12)$
$P = 80(9.9540) + 2(51.2482)$
$= \$898.82$

4.37 $2,000,000 = A(P/A,3\%,8) + 50,000(P/G,3\%,8)$
$2,000,000 = A(7.0197) + 50,000(23.4806)$
$A = \$117,665$

4.38 $P = 1000 + 2000(P/A,1.5\%,12) + 3000(P/A,1.5\%,16)(P/F,1.5\%,12)$
$= 1000 + 2000(10.9075) + 3000(14.1313)(0.8364)$
$= \$58,273$

4.39 First find P in quarter –1 and then use A/P to get A in quarters 0-8.
$P_{-1} = 1000(P/F,4\%,2) + 2000(P/A,4\%,2)(P/F,4\%,2) + 3000(P/A,4\%,4)(P/F,4\%,5)$
$= 1000(0.9246) + 2000(1.8861)(0.9246) + 3000(3.6299)(0.8219)$
$= \$13,363$

$A = 13,363(A/P,4\%,9)$
$= 13,363(0.13449)$
$= \$1797.19$

4.40 Move deposits to end of compounding periods and then find F.
$F = 1800(F/A,3\%,30)$
$= 1800(47.5754)$
$= \$85,636$

4.41 Move withdrawals to beginning of periods and then find F.
$F = (10,000 – 1000)(F/P,4\%,6) – 1000(F/P,4\%,5) – 1000(F/P,4\%,3)$
$= 9000(1.2653) – 1000(1.2167) – 1000(1.1249)$
$= \$9046$

4.42 Move withdrawals to beginning of periods and deposits to end; then find F.
$F = 1600(F/P,4\%,5) +1400(F/P,4\%,4) – 2600(F/P,4\%,3) + 1000(F/P,4\%,2)$
$-1000(F/P,4\%,1)$
$= 1600(1.2167) + 1400(1.1699) – 2600(1.1249) + 1000(1.0816) –1000(1.04)$
$= \$701.44$

4.43 Move monthly costs to end of quarter and then find F.
Monthly costs = $495(6)(2) = \$5940$
End of quarter costs = $5940(3) = \$17,820$
$F = 17,820(F/A,1.5\%,4)$
$= 17,820(4.0909)$
$= \$72,900$

4.44 $i = e^{0.13} - 1$
$= 13.88\%$

4.45 $i = e^{0.12} - 1$
$= 12.75\%$

4.46 $0.127 = e^{r} - 1$
$r/yr = 11.96\%$
$r/quarter = 2.99\%$

4.47 15% per year = 15/12 = 1.25% per month
$i = e^{0.0125} - 1 = 1.26\%$ per month

$F = 100{,}000(F/A,1.26\%,24)$
$= 100{,}000\{[1 + 0.0126)^{24} - 1]/0.0126\}$
$= 100{,}000(27.8213)$
$= \$2{,}782{,}130$

4.48 18% per year = 18/12 = 1.50% per month
$i = e^{0.015} - 1 = 1.51\%$ per month
$P = 6000(P/A,1.51\%,60)$
$= 6000\{[(1 + 0.0151)^{60} - 1]/[0.0151(1 + 0.0151)^{60}]\}$
$= 6000(39.2792)$
$= \$235{,}675$

4.49 $i = e^{0.02} - 1 = 2.02\%$ per month
$A = 50(A/P,2.02\%,36)$
$= 50\{[0.0202(1 + 0.0202)^{36}]/[(1 + 0.0202)^{36} - 1]\}$
$= 50(0.03936)$
$= \$1{,}968{,}000$

4.50 $i = e^{0.06} - 1 = 6.18\%$ per year
$P = 85{,}000(P/F,6.18\%,4)$
$= 85{,}000[1/(1 + 0.0618)^{4}$
$= 85{,}000(0.78674)$
$= \$66{,}873$

4.51 $i = e^{0.015} - 1 = 1.51\%$ per month
$2P = P(1 + 0.0151)^{n}$
$2.000 = (1.0151)^{n}$

Take log of both sides and solve for n
$n = 46.2$ months

4.52 Set up F/P equation in months.

$$3P = P(1 + i)^{60}$$
$$3.000 = (1 + i)^{60}$$
$$1.01848 = 1 + i$$
$$i = 1.85\% \text{ per month (effective)}$$

4.53 P = 150,000(P/F,12%,2)(P/F,10%,3)
= 150,000(0.7972)(0.7513)
= $89,840

4.54 F = 50,000(F/P,10%,4)(F/P,1%,48)
= 50,000(1.4641)(1.6122)
= $118,021

4.55 (a) First move cash flow in years 0-4 to year 4 at i = 12%.

F = 5000(F/P,12%,4) + 6000(F/A,12%,4)
= 5000(1.5735) + 6000(4.7793)
= $36,543

Now move the total to year 5 at i = 20%.

F = 36,543(F/P,20%,1) + 9000
= 36,543(1.20) + 9000
= $52,852

(b) Substitute A values for annual cash flows, including year 5 with the factor (F/P,20%,0) = 1.00

52,852 = A{[(F/P,12%,4) + (F/A,12%,4)](F/P,20%,1) + (F/P,20%,0)}
= A{[(1.5735) + (4.7793)](1.20) + 1.00}
= A(8.62336)

A = $6129 per year for years 0 through 5 (a total of 6 A values).

4.56 First find P.

P = 5000(P/A,10%,3) + 7000(P/A,12%,2)(P/F,10%3)
= 5000(2.4869) + 7000(1.6901)(0.7513)
= 12,434.50 + 8888.40
= $21,323

Now substitute A values for cash flows.

$$21{,}323 = A(P/A,10\%,3) + A(P/A,12\%,2)(P/F,10\%3)$$
$$= A(2.4869) + A(1.6901)(0.7513)$$
$$= A(3.7567)$$
$$A = \$5676$$

FE Review Solutions

4.57 Answer is (b)

4.58 Answer is (d)

4.59 $i/yr = (1 + 0.01)^{12} - 1 = 0.1268 = 12.68\%$
Answer is (d)

4.60 $i/quarter = e^{0.045} - 1 = 0.0460 = 4.60\%$
Answer is (c)

4.61 Answer is (d)

4.62 Answer is (a)

4.63 Find annual rate per year for each condition.
$i/yr = 22\%$ simple
$i/yr = (1 + 0.21/4)^4 - 1 = 0.2271 = 22.7\ \%$
$i/yr = (1 + 0.21/12)^{12} - 1 = 0.2314 = 23.14\ \%$
$i/yr = (1 + 0.22/2)^2 - 1 = 0.2321 = 23.21\ \%$

Answer is (a)

4.64 $i/\text{semi-annual} = e^{0.02} - 1 = 0.0202 = 2.02\%$
Answer is (b)

4.65 Answer is (c)

4.66 $P = 30(P/A,0.5\%,60)$
$= \$1552$
Answer is (b)

4.67 $P = 7 + 7(P/A,4\%,25)$
$= \$116.3547$ million
Answer is (c)

4.68 Answer is (a)

4.69 Answer is (d)

4.70 PP>CP; must use i over PP of 1 year. Therefore, n = 7
Answer is (a)

4.71 $P = 1{,}000{,}000 + 1{,}050{,}000\{[1- [(1 + 0.05)^{12}/(1 + 0.01)^{12}]\}/(0.01-0.05)$
$= \$16{,}585{,}447$
Answer is (b)

4.72 Answer is (d)

4.73 Deposit in year 1 $= 1250/(1 + 0.05)^3$
$= \$1079.80$
Answer is (d)

4.74 $A = 40{,}000(A/F,5\%,8)$
$= 40{,}000(0.10472)$
$= \$4188.80$
Answer is (c)

4.75 $A = 800{,}000(A/P,3\%,12)$
$= 800{,}000(0.10046)$
$= \$80{,}368$
Answer is (c)

Case Study Solution

1. Plan C:15-Year Rate - The calculations for this plan are the same as those for plan A, except that i = 9 ½% per year and n = 180 periods instead of 360. However, for a 5% down payment, the P&I is now $1488.04 which will yield a total payment of $1788.04. This is greater than the $1600 maximum payment available. Therefore, the down payment will have to be increased to $25,500, making the loan amount $124,500. This will make the P&I amount $1300.06 for a total monthly payment of $1600.06.

The amount of money required up front is now \$28,245 (the origination fee has also changed). The plan C values for F_{1C}, F_{2C}, and F_{3C} are shown below.

$$F_{1C} = (40{,}000 - 28{,}245)(F/P,0.25\%,120)$$
$$= \$15{,}861.65$$

$$F_{2C} = 0$$

$$F_{3C} = 170{,}000 - [124{,}500(F/P,9.5\%/12,120)$$
$$- 1300.06(F/A,9.5\%/12,120)]$$
$$= \$108{,}097.93$$

$$F_C = F_{1C} + F_{2C} + F_{3C}$$
$$= \$123{,}959.58$$

The future worth of Plan C is considerably higher than either Plan A (\$87,233) or Plan B (\$91,674). Therefore, Plan C with a 15-year fixed rate is the preferred financing method.

2. Plan A

Loan amount = \$142,500
Balance after 10 years = \$129,582.48
Equity = 142,500 – 129,582.48 = \$12,917.52

Total payment made = 1250.56(120) = \$150,067.20

Interest paid = 150,067.20 – 12,917.52 = \$137,149.68

3. Amount paid through first 3 yrs = 1146.58 (36) = \$41,276.88
Principal reduction through first 3 yrs = 142,500 – 139,297.08 = \$3,202.92
Interest paid first 3 yrs = 41,276.88 – 3202.92 = \$38,073.96

Amount paid year 4 = 1195.67(12) = 14,348.04
Principal reduction year 4 = 139,297.08 – 138,132.42 = 1164.66
Interest paid year 4 = 14,348.04 – 1164.66 = 13,183.38

Total interest paid in 4 years = 38,073.96 + 13,183.38 = \$51,257.34

4. Let DP = down payment
Fixed fees = 300 + 200 + 200 + 350 + 150 + 300 = \$1500
Available for DP = 40,000 – 1500 – (loan amount)(0.01)
where loan amount = 150,000 – DP

$$
\begin{aligned}
DP &= 40{,}000 - 1500 - [(150{,}000 - DP)(0.01)] \\
&= 40{,}000 - 1500 - 1500 + 0.01DP \\
0.99DP &= 37{,}000 \\
DP &= \$37{,}373.73
\end{aligned}
$$

check: origination fee = (150,000 – 37,373.73)(0.01) = 1126.26
available DP = 40,000 – 1500 – 1126.26 = $37,373.73

5. Amount financed = $142,500

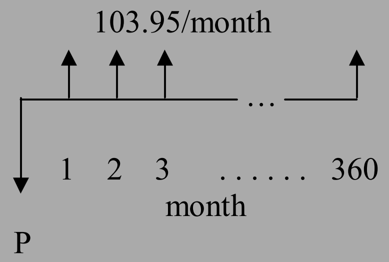
	Increase from one interest rate to the other
Monthly P&I @ 10% = $1,250.56	
Monthly P&I @ 11% = 142,500(A/P,11%/12, 60)	-----
$A = (142{,}500)\left[\dfrac{(0.009167)(1+0.009167)^{360}}{(1+0.009167)^{360}-1}\right] = \$1357.06$	106.50
Monthly P&I @ 12% = $1465.77	108.71
Monthly P&I @ 13% = $1576.33	110.56
Monthly P&I @ 14% = $1688.44	112.11

Increase varies:
10% to 11% = $106.50
11% to 12% = 108.71
12% to 13% = 110.56
13% to 14% = 112.11

6. In buying down interest, you must give lender money now instead of money later. Therefore, to go from 10% to 9%, lender must recover the additional 1% now.

P&I @ 10% = 1250.54
P&I @ 9% = 1146.59

Difference = $103.95/month



$$
\begin{aligned}
P &= 103.95(P/A,10\%/12,360) \\
&= 103.95(113.9508) \\
&= \$11{,}845.19
\end{aligned}
$$

Chapter 5

Present Worth Analysis

Solutions to Problems

5.1 A service alternative is one that has only costs (no revenues).

5.2 (a) For independent projects, select all that have PW $\geq$ 0; (b) For mutually exclusive projects, select the one that has the highest numerical value.

5.3 (a) Service; (b) Revenue; (c) Revenue; (d) Service; (e) Revenue; (f) Service

5.4 (a) Total possible = 2^5 = 32

(b) Because of restrictions, cannot have any combinations of 3,4, or 5. Only 12 are acceptable: DN, 1, 2, 3, 4, 5, 1&3, 1&4, 1&5, 2&3, 2&4, and 2&5.

5.5 Equal service means that the alternatives 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 of the lives* of the alternatives.

5.7 Capitalized cost represents the present worth of service for an infinite time. Real world examples that might be analyzed using CC would be Yellowstone National Park, Golden Gate Bridge, Hoover Dam, etc.

5.8 PW_{old} = -1200(3.50)(P/A,15%,5)
= -4200(3.3522)
= \$-14,079

PW_{new} = -14,000 – 1200(1.20)(P/A,15%,5)
= -14,000 – 1440(3.3522)
= \$-18,827

Keep old brackets

5.9 PW_A = -80,000 – 30,000(P/A,12%,3) + 15,000(P/F,12%,3)
= -80,000 – 30,000(2.4018) + 15,000(0.7118)
= \$-141,377

$$PW_B = -120{,}000 - 8{,}000(P/A,12\%,3) + 40{,}000(P/F,12\%,3)$$
$$= -120{,}000 - 8{,}000(2.4018) + 40{,}000(0.7118)$$
$$= \$-110{,}742$$

Select Method B

5.10 Bottled water: Cost/mo = -(2)(0.40)(30) = $24.00

$$PW = -24.00(P/A,0.5\%,12)$$
$$= -24.00(11.6189)$$
$$= \$-278.85$$

Municipal water: Cost/mo = -5(30)(2.10)/1000 = $0.315

$$PW = -0.315(P/A,0.5\%,12)$$
$$= -0.315(11.6189)$$
$$= \$-3.66$$

5.11 $$PW_{single} = -4000 - 4000(P/A,12\%,4)$$
$$= -4000 - 4000(3.0373)$$
$$= \$-16{,}149$$

$$PW_{site} = \$-15{,}000$$

Buy the site license

5.12 $$PW_{variable} = -250{,}000 - 231{,}000(P/A,15\%,6) - 140{,}000(P/F,15\%,4) + 50{,}000(P/F,15\%,6)$$
$$= -250{,}000 - 231{,}000(3.7845) - 140{,}000(0.5718) + 50{,}000(0.4323)$$
$$= \$-1{,}182{,}656$$

$$PW_{dual} = -224{,}000 - 235{,}000(P/A,15\%,6) - 26{,}000(P/F,15\%,3) + 10{,}000(P/F,15\%,6)$$
$$= -224{,}000 - 235{,}000(3.7845) - 26{,}000(0.6575) + 10{,}000(0.4323)$$
$$= \$-1{,}126{,}130$$

Select dual speed machine

5.13 $$PW_{JX} = -205{,}000 - 29{,}000(P/A,10\%,4) - 203{,}000(P/F,10\%,2) + 2000(P/F,10\%,4)$$
$$= -205{,}000 - 29{,}000(3.1699) - 203{,}000(0.8264) + 2000(0.6830)$$
$$= \$-463{,}320$$

$$PW_{KZ} = -235{,}000 - 27{,}000(P/A,10\%,4) + 20{,}000(P/F,10\%,4)$$
$$= -235{,}000 - 27{,}000(3.1699) + 20{,}000(0.6830)$$
$$= \$-306{,}927$$

Select material KZ

5.14 $PW_K = -160{,}000 - 7000(P/A,2\%,16) - 120{,}000(P/F,2\%,8) + 40{,}000(P/F,2\%,16)$
$= -160{,}000 - 7000(13.5777) - 120{,}000(0.8535) + 40{,}000(0.7284)$
$= \$-328{,}328$

$PW_L = -210{,}000 - 5000(P/A,2\%,16) + 26{,}000(P/F,2\%,16)$
$= -210{,}000 - 5000(13.5777) + 26{,}000(0.7284)$
$= \$-258{,}950$
Select process L

5.15 $PW_{plastic} = -75{,}000 - 27{,}000(P/A,10\%,6) - 75{,}000(P/F,10\%,2)$
$- 75{,}000(P/F,10\%,4)$
$= -75{,}000 - 27{,}000(4.3553) - 75{,}000(0.8264) - 75{,}000(0.6830)$
$= \$-305{,}798$

$PW_{aluminum} = -125{,}000 - 12{,}000(P/A,10\%,6) - 95{,}000(P/F,10\%,3)$
$+ 30{,}000(P/F,10\%,6)$
$= -125{,}000 - 12{,}000(4.3553) - 95{,}000(0.7513) + 30{,}000(0.5645)$
$= \$-231{,}702$

Use aluminum case

5.16 $i/year = (1 + 0.03)^2 - 1 = 6.09\%$
$PW_A = -1{,}000{,}000 - 1{,}000{,}000(P/A,6.09\%,5)$
$= -1{,}000{,}000 - 1{,}000{,}000(4.2021)$ (by equation)
$= \$-5{,}202{,}100$

$PW_B = -600{,}000 - 600{,}000(P/A,3\%,11)$
$= -600{,}000 - 600{,}000(9.2526)$
$= \$-6{,}151{,}560$

$PW_C = -1{,}500{,}000 - 500{,}000(P/F,3\%,4) - 1{,}500{,}000(P/F,3\%,6)$
$- 500{,}000(P/F,3\%,10)$
$= -1{,}500{,}000 - 500{,}000(0.8885) - 1{,}500{,}000(0.8375) - 500{,}000(0.7441)$
$= \$-3{,}572{,}550$

Select plan C

5.17 $FW_{solar} = -12{,}600(F/P,10\%,4) - 1400(F/A,10\%,4)$
$= -12{,}600(1.4641) - 1400(4.6410)$
$= \$-24{,}945$

$FW_{line} = -11{,}000(F/P,10\%,4) - 800(F/P,10\%,4)$
$= -11{,}000(1.4641) - 800(4.6410)$
$= \$-19{,}818$
Install power line

5.18 $FW_{20\%} = -100(F/P,10\%,15) - 80(F/A,10\%,15)$
$= -100(4.1772) - 80(31.7725)$
$= \$-2959.52$

$FW_{35\%} = -240(F/P,10\%,15) - 65(F/A,10\%,15)$
$= -240(4.1772) - 65(31.7725)$
$= \$-3067.74$

20% standard is slightly more economical

5.19 $FW_{purchase} = -150{,}000(F/P,15\%,6) + 12{,}000(F/A,15\%,6) + 65{,}000$
$= -150{,}000(2.3131) + 12{,}000(8.7537) + 65{,}000$
$= \$-176{,}921$

$FW_{lease} = -30{,}000(F/A,15\%,6)(F/P,15\%,1)$
$= - 30{,}000(8.7537)(1.15)$
$= \$-302{,}003$

Purchase the clamshell

5.20 $FW_{HSS} = -3500(F/P,1\%,6) - 2000(F/A,1\%,6) - 3500(F/P,1\%,3)$
$= -3500(1.0615) - 2000(6.1520) - 3500(1.0303)$
$= \$-19{,}625$

$FW_{gold} = -6500(F/P,1\%,6) - 1500(F/A,1\%,6)$
$= -6500(1.0615) - 1500(6.1520)$
$= \$-16{,}128$

$FW_{titanium} = -7000(F/P,1\%,6) - 1200(F/A,1\%,6)$
$= -7000(1.0615) - 1200(6.1520)$
$= \$-14{,}813$

Use titanium nitride bits

5.21 $FW_A = -300{,}000(F/P,12\%,10) - 900{,}000(F/A,12\%,10)$
$= -300{,}000(3.1058) - 900{,}000(17.5487)$
$= \$-16{,}725{,}570$

$FW_B = -1{,}200{,}000(F/P,12\%,10) - 200{,}000(F/A,12\%,10)$
$- 150{,}000(F/A,12\%,10)$
$= -1{,}200{,}000(3.1058) - 200{,}000(17.5487) - 150{,}000(17.5487)$
$= \$-9{,}869{,}005$

Select Plan B

5.22 CC = -400,000 – 400,000(A/F,6%,2)/0.06
= -400,000 – 400,000(0.48544)/0.06
=$-3,636,267

5.23 CC = -1,700,000 – 350,000(A/F,6%,3)/0.06
= - 1,700,000 – 350,000(0.31411)/0.06
= $-3,532,308

5.24 CC = -200,000 – 25,000(P/A,12%,4)(P/F,12%,1) – [40,000/0.12])P/F,12%,5)
= -200,000 – 25,000(3.0373)(0.8929) – [40,000/0.12])(0.5674)
= $-456,933

5.25 CC = -250,000,000 – 800,000/0.08 – [950,000(A/F,8%,10)]/0.08
- 75,000(A/F,8%,5)/0.08
= -250,000,000 – 800,000/0.08 – [950,000(0.06903)]/0.08
-75,000(0.17046)/0.08
= $-251,979,538

5.26 Find AW and then divide by i.

AW = [-82,000(A/P,12%,4) – 9000 +15,000(A/F,12%,4)]
= [-82,000(0.32923) – 9000 +15,000(0.20923)]/0.12
= $-32,858.41

CC = -32,858.41/0.12
= $-273,820

5.27 (a) P_{29} = 80,000/0.08
= $1,000,000

(b) P_0 = 1,000,000(P/F,8%,29)
= 1,000,000(0.1073)
= $107,300

5.28 Find AW of each plan, then take difference, and divide by i.
AW_A = -50,000(A/F,10%,5)
= -50,000(0.16380)
= $-8190

AW_B = -100,000(A/F,10%,10)
= -100,000(0.06275)
= $-6275

CC of difference = (8190 - 6275)/0.10
= $19,150

5.29 $CC = -3{,}000{,}000 – 50{,}000(P/A,1\%,12) – 100{,}000(P/A,1\%,13)(P/F,1\%,12) - [50{,}000/0.01](P/F,1\%,25)$

$= -3{,}000{,}000 – 50{,}000(11.2551) – 100{,}000(12.1337)(0.8874) - [50{,}000/0.01](0.7798)$

$= \$-8{,}538{,}500$

5.30 $CC_{petroleum} = [-250{,}000(A/P,10\%,6) –130{,}000 + 400{,}000 + 50{,}000(A/F,10\%,6)]/0.10$

$= [-250{,}000(0.22961) –130{,}000 + 400{,}000 + 50{,}000(0.12961)]/0.10$

$= \$2{,}190{,}780$

$CC_{inorganic} = [-110{,}000(A/P,10\%,4) – 65{,}000 + 270{,}000 + 20{,}000(A/F,10\%,4)]/0.10$

$= [-110{,}000(0.31547) – 65{,}000 + 270{,}000 + 20{,}000(0.21547)]/0.10$

$= \$1{,}746{,}077$

Petroleum-based alternative has a larger profit.

5.31 $CC = 100{,}000 + 100{,}000/0.08$

$= \$1{,}350{,}000$

5.32 $CC_{pipe} = -225{,}000{,}000 – 10{,}000{,}000/0.10 – [50{,}000{,}000(A/F,10\%,40)]/0.10$

$= -225{,}000{,}000 – 10{,}000{,}000/0.10 – [50{,}000{,}000(0.00226)]/0.10$

$= \$-326{,}130{,}000$

$CC_{canal} = -350{,}000{,}000 – 500{,}000/0.10$

$= \$-355{,}000{,}000$

Build the pipeline

5.33 $CC_E = [-200{,}000(A/P,3\%,8) + 30{,}000 + 50{,}000(A/F,3\%,8)]/0.03$

$= [-200{,}000(0.14246) + 30{,}000 + 50{,}000(0.11246)]/0.03$

$= \$237{,}700$

$CC_F = [-300{,}000(A/P,3\%,16) + 10{,}000 + 70{,}000(A/F,3\%,16)]/0.03$

$= [-300{,}000(0.07961) + 10{,}000 + 70{,}000(0.04961)]/0.03$

$= \$-347{,}010$

$CC_G = -900{,}000 + 40{,}000/0.03$

$= \$433{,}333$

Select alternative G.

5.34 No-return payback refers to the time required to recover an investment at i = 0%.

5.35 The alternatives that have large cash flows beyond the date where other alternatives recover their investment might actually be more attractive *over the entire lives* of the alternatives (based on PW, AW, or other evaluation methods).

5.36 $0 = - 40{,}000 + 6000(P/A,8\%,n) + 8000(P/F,8\%,n)$

Try $n = 9$: $0 \neq +1483$

Try $n = 8$: $0 \neq -1198$

n is between 8 and 9 years

5.37 $0 = -22{,}000 + (3500 – 2000)(P/A,4\%,n)$

$(P/A,4\%,n) = 14.6667$

n is between 22 and 23 *quarters* or 5.75 years

5.38 $0 = -70{,}000 + (14{,}000 – 1850)(P/A,10\%,n)$

$(P/A,10\%,n) = 5.76132$

n is between 9 and 10; therefore, it would take 10 years.

5.39 (a) $n = 35{,}000/(22{,}000 – 17{,}000) = 7$ years

(b) $0 = -35{,}000 + (22{,}000 – 17{,}000)(P/A,10\%,n)$

$(P/A,10\%,n) = 7.0000$

n is between 12 and 13; therefore, n = 13 years.

5.40 $–250{,}000 – 500n + 250{,}000(1 + 0.02)^n = 100{,}000$

Try $n = 18$: $98{,}062 < 100{,}000$

Try $n = 19$: $104{,}703 > 100{,}000$

n is 18.3 months or 1.6 years.

5.41 Payback: Alt A: $0 = -300{,}000 + 60{,}000(P/A,8\%,n)$

$(P/A,8\%,n) = 5.0000$

n is between 6 and 7 years

Alt B: $0 = -300{,}000 + 10{,}000(P/A,8\%,n) + 15{,}000(P/G,8\%,n)$

Try $n = 7$: $0 > -37{,}573$

Try $n = 8$: $0 < +24{,}558$

n is between 7 and 8 years

Select A

PW for 10 yrs: Alt A: $PW = -300{,}000 + 60{,}000(P/A,8\%,10)$
$= -300{,}000 + 60{,}000(6.7101)$
$= \$102{,}606$

Alt B: $PW = -300{,}000 + 10{,}000(P/A,8\%,10) + 15{,}000(P/G,8\%,10)$
$= -300{,}000 + 10{,}000(6.7101) + 15{,}000(25.9768)$
$= \$156{,}753$

Select B

Income for Alt B increases rapidly in later years, which is not accounted for in payback analysis.

5.42 $LCC = -6.6 – 3.5(P/F,7\%,1) – 2.5(P/F,7\%,2) – 9.1(P/F,7\%,3) – 18.6(P/F,7\%,4)$
$- 21.6(P/F,7\%,5) - 17(P/A,7\%,5)(P/F,7\%,5) – 14.2(P/A,7\%,10)(P/F,7\%,10)$
$- 2.7(P/A,7\%,3)(P/F,7\%,17)$
$= -6.6 – 3.5(0.9346) – 2.5(0.8734) – 9.1(0.8163) – 18.6(0.7629) - 21.6(0.7130)$
$- 17(4.1002)(0.7130) – 14.2(7.0236)(0.5083) - 2.7(2.6243)(0.3166)$
$= \$-151{,}710{,}860$

5.43 $LCC = – 2.6(P/F,6\%,1) – 2.0(P/F,6\%,2) – 7.5(P/F,6\%,3) – 10.0(P/F,6\%,4)$
$-6.3(P/F,6\%,5) – 1.36(P/A,6\%,15)(P/F,6\%,5) -3.0(P/F,6\%,10)$
$- 3.7(P/F,6\%,18)$
$= – 2.6(0.9434) – 2.0(0.8900) – 7.5(0.8396) – 10.0(0.7921) -6.3(0.7473)$
$– 1.36(9.7122)(0.7473) -3.0(0.5584) - 3.7(0.3503)$
$= \$-36{,}000{,}921$

5.44 $LCC_A = -750{,}000 – (6000 + 2000)(P/A,0.5\%,240) – 150{,}000[(P/F,0.5\%,60)$
$+ (P/F,0.5\%,120) + (P/F,0.5\%,180)]$
$= -750{,}000 – (8000)(139.5808) – 150{,}000[(0.7414) + (0.5496) + (0.4075)]$
$= \$-2{,}121{,}421$

$LCC_B = -1.1 – (3000 + 1000)(P/A,0.5\%,240)$
$= -1.1 – (4000)(139.5808)$
$= \$-1{,}658{,}323$

Select proposal B.

5.45 $LCC_A = -250{,}000 – 150{,}000(P/A,8\%,4) – 45{,}000 – 35{,}000(P/A,8\%,2)$
$-50{,}000(P/A,8\%,10) – 30{,}000(P/A,8\%,5)$
$= -250{,}000 – 150{,}000(3.3121) – 45{,}000 – 35{,}000(1.7833)$
$-50{,}000(6.7101) – 30{,}000(3.9927)$
$= \$-1{,}309{,}517$

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

$LCC_C = -175,000(P/A,8\%,10)$
$= -175,000(6.7101)$
$= \$-1,174,268$

Select alternative B.

5.46 $I = 10,000(0.06)/4 = \$150$ every 3 months

5.47 $800 = (V)(0.04)/2$
$V = \$40,000$

5.48 $1500 = (20,000)(b)/2$
$b = 15\%$

5.49 Bond interest rate and market interest rate are the same.
Therefore, PW = face value = \$50,000.

5.50 $I = (50,000)(0.04)/4$
$= \$500$ every 3 months

$PW = 500(P/A,2\%,60) + 50,000(P/F,2\%,60)$
$= 500(34.7609) + 50,000(0.3048)$
$= \$32,620$

5.51 There are 17 years or 34 semiannual periods remaining in the life of the bond.

$I = 5000(0.08)/2$
$= \$200$ every 6 months

$PW = 200(P/A,5\%,34) + 5000(P/F,5\%,34)$
$= 200(16.1929) + 5000(0.1904)$
$= \$4190.58$

5.52 $I = (V)(0.07)/2$
$201,000,000 = I(P/A,4\%,60) + V(P/F,4\%,60)$

Try V = 226,000,000: $201,000,000 > 200,444,485$
Try V = 227,000,000: $201,000,000 < 201,331,408$

By interpolation, V = \$226,626,340

5.53 (a) $I = (50{,}000)(0.12)/4$
$= \$1500$

Five years from now there will be 15(4) = 60 payments left. PW_5 then is:

$$PW_5 = 1500(P/A,2\%,60) + 50{,}000(P/F,2\%,60)$$
$$= 1500(34.7609) + 50{,}000(0.3048)$$
$$= \$67{,}381$$

(b) Total $= 1500(F/A,3\%,20) + 67{,}381$ [PW in year 5 from (a)]
$= 1500(26.8704) + 67{,}381$
$= \$107{,}687$

FE Review Solutions

5.54 Answer is (b)

5.55 $PW = 50{,}000 + 10{,}000(P/A,10\%,15) + [20{,}000/0.10](P/F,10\%,15)$
$= \$173{,}941$
Answer is (c)

5.56 $CC = [40{,}000/0.10](P/F,10\%,4)$
$= \$273{,}200$
Answer is (c)

5.57 $CC = [50{,}000/0.10](P/F,10\%,20)(A/F,10\%,10)$
$= \$4662.33$
Answer is (b)

5.58 $PW_X = -66{,}000 - 10{,}000(P/A,10\%,6) + 10{,}000(P/F,10\%,6)$
$= -66{,}000 - 10{,}000(4.3553) + 10{,}000(0.5645)$
$= \$-103{,}908$
Answer is (c)

5.59 $PW_Y = -46{,}000 - 15{,}000(P/A,10\%,6) - 22{,}000(P/F,10\%,3) + 24{,}000(P/F,10\%,6)$
$= -46{,}000 - 15{,}000(4.3553) - 22{,}000(0.7513) + 24{,}000(0.5645)$
$= \$-114{,}310$
Answer is (d)

5.60 $CC_X = [-66{,}000(A/P,10\%,6) - 10{,}000 + 10{,}000(A/F,10\%,6)]/0.10$
$= [-66{,}000(0.22961) - 10{,}000 + 10{,}000(0.12961)]/0.10$
$= \$-238{,}582$
Answer is (d)

5.61 CC = -10,000(A/P,10%,5)/0.10
= -10,000(0.26380)/0.10
= $-26,380
Answer is (b)

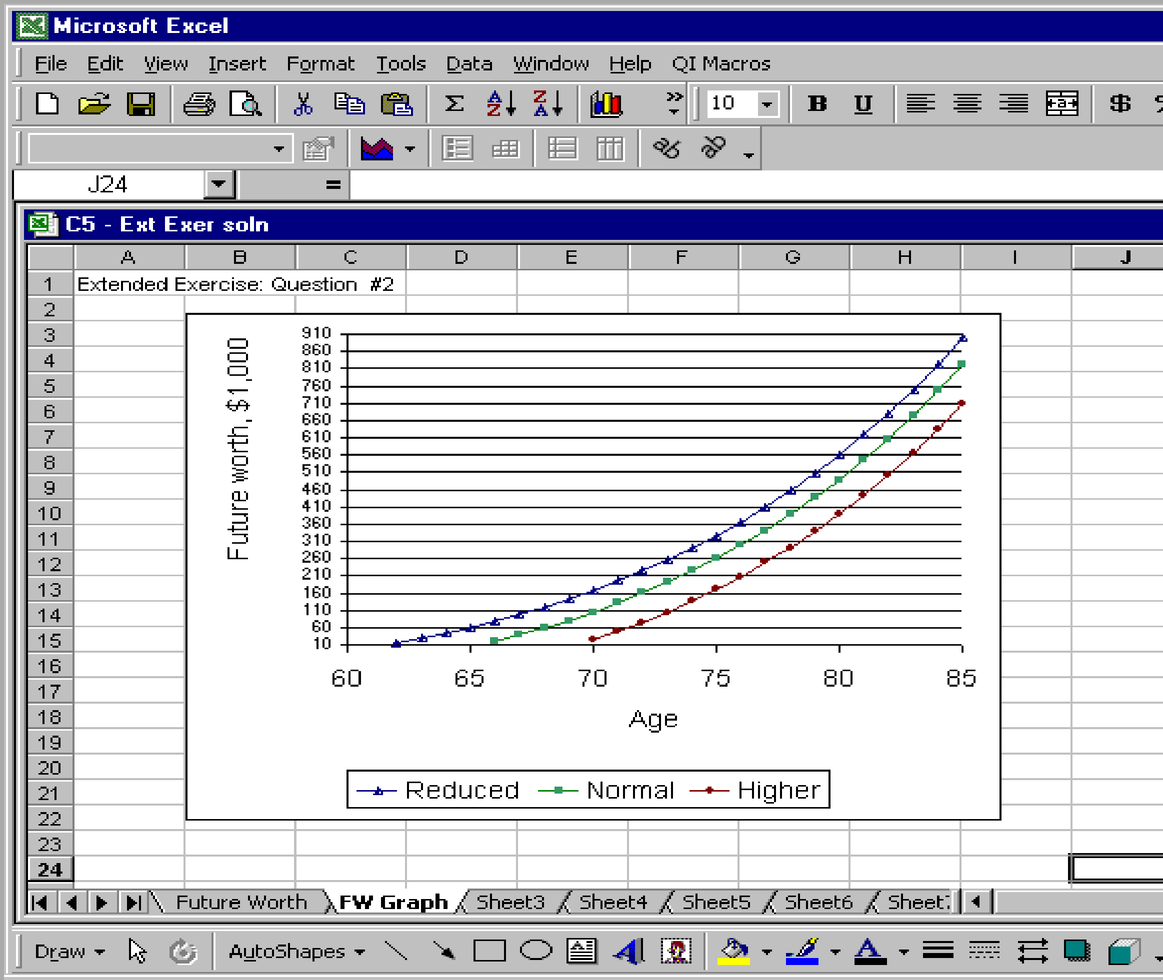
5.62 Answer is (c)   5.63 Answer is (b)   5.64 Answer is (a)   5.65 Answer is (b)

Extended Exercise Solution Questions 1, 3 and 4:

Microsoft Excel — C5 - Ext Exer soln

	A	B	C	D	E	F	G	H	I
1	Rate =	8.00%							
2		# remaining		Future worth		Future worth		Future worth	Spousal
3	Age	Years	Reduced	Reduced	Normal	Normal	Higher	Higher	benefits
4	61	25							
5	62	24	$ 13,500	$ 13,500					
6	63	23	$ 13,500	$ 28,080					
7	64	22	$ 13,500	$ 43,826					
8	65	21	$ 13,500	$ 60,833					
9	66	20	$ 13,500	$ 79,199	$ 18,000	$ 18,000			$ 19,200
10	67	19	$ 13,500	$ 99,035	$ 18,000	$ 37,440			$ 19,200
11	68	18	$ 13,500	$ 120,458	$ 18,000	$ 58,435			$ 19,200
12	69	17	$ 13,500	$ 143,594	$ 18,000	$ 81,110			$ 19,200
13	70	16	$ 13,500	$ 168,582	$ 18,000	$ 105,599	$ 23,400	$ 23,400	$ 19,200
14	71	15	$ 13,500	$ 195,569	$ 18,000	$ 132,047	$ 23,400	$ 48,672	$ 19,200
15	72	14	$ 13,500	$ 224,714	$ 18,000	$ 160,610	$ 23,400	$ 75,966	$ 19,200
16	73	13	$ 13,500	$ 256,191	$ 18,000	$ 191,459	$ 23,400	$ 105,443	$ 19,200
17	74	12	$ 13,500	$ 290,187	$ 18,000	$ 224,776	$ 23,400	$ 137,278	$ 19,200
18	75	11	$ 13,500	$ 326,901	$ 18,000	$ 260,758	$ 23,400	$ 171,661	$ 19,200
19	76	10	$ 13,500	$ 366,554	$ 18,000	$ 299,619	$ 23,400	$ 208,794	$ 19,200
20	77	9	$ 13,500	$ 409,378	$ 18,000	$ 341,588	$ 23,400	$ 248,897	$ 19,200
21	78	8	$ 13,500	$ 455,628	$ 18,000	$ 386,915	$ 23,400	$ 292,209	$ 19,200
22	79	7	$ 13,500	$ 505,578	$ 18,000	$ 435,869	$ 23,400	$ 338,986	$ 19,200
23	80	6	$ 13,500	$ 559,525	$ 18,000	$ 488,738	$ 23,400	$ 389,504	$ 19,200
24	81	5	$ 13,500	$ 617,787	$ 18,000	$ 545,837	$ 23,400	$ 444,065	$ 19,200
25	82	4	$ 13,500	$ 680,709	$ 18,000	$ 607,504	$ 23,400	$ 502,990	$ 19,200
26	83	3	$ 13,500	$ 748,666	$ 18,000	$ 674,104	$ 23,400	$ 566,629	$ 19,200
27	84	2	$ 13,500	$ 822,059	$ 18,000	$ 746,033	$ 23,400	$ 635,359	$ 19,200
28	85	1	$ 13,500	$ 901,324	$ 18,000	$ 823,715	$ 23,400	$ 709,588	19200
29	Total FW		**$ 901,324**		**$ 823,715**		**$ 709,588**		
30							PW now of spouse benefits =		**$27,526**
31							FW at age 85 of spouse benefits =		**$878,630**
32	Solutions:								
33	#1: FW of reduced = $901,324				#3: PW for spouse = $27,526				
34	#1: FW of normal = $823,715								
35	#1: FW of higher = $709,588				#4: FW for spouse = $878,630				

Question 2:



Case Study Solution

1. Set first cost of toilet equal to monthly savings and solve for n:

$$[(115.83 - 76.12) + 50](A/P,0.75\%,n) = 2.1(0.76 + 0.62)$$
$$89.71(A/P,0.75\%,n) = 2.898$$
$$(A/P,0.75\%,n) = 0.03230$$

From 0.75% interest table, n is between 30 and 36 months

By interpolation, n = 35 months or 2.9 years

2. If the toilet life were to decrease by 50% to 2.5 years, then the homeowner would not breakeven at any interest rate (2.6 years is required at 0% and longer times would be required for $i > 0\%$). If the interest rate were to increase by more than 50% (say from 9% to 15%), the payback period would increase from 2.9 years (per above solution) to a little less than 3.3 years (from 1.25% interest table). Therefore, the payback period is much more sensitive to the toilet life than to the interest rate.

3. cost/month = 76.12 (A/P,0.5%,60)
   = 76.12 (0.01933)
   = \$1.47

   CCF/month = 2.1 + 2.1
   = 4.2

   cost/CCF = 1.47/4.2
   = \$0.35/CCF or \$0.47/1000 gallons (vs \$0.40/1000 gallons at 0% interest)

4. (a) If 100% of the \$115.83 cost of the toilet is rebated, the cost to the city at 0% interest is

$$c = \frac{115.83}{(2.1 + 2.1)\ (12)\ (5)}$$

= \$0.46/CCF or \$0.61/1000 gal (vs \$0.40/1000 gal at 75% rebate)

This is still far below the city's cost of \$1.10/1000 gallons. Therefore, the success of the program is not sensitive to the percentage of cost rebated.

(b) Use the same relation for cost/month as in question 3 above, except with varying interest rates, the values shown in the table below are obtained for n = 5 years.

Interest Rate, %	4	6	8	10	12	15
\$ / CCF	0.33	0.35	0.37	0.39	0.40	0.43
\$/1000 gal	0.45	0.47	0.49	0.51	0.54	0.58

The results indicate that even at an interest rate of 15% per year, the cost at \$0.58/1000 gallons is significantly below the city's cost of \$1.10/1000 gallons. Therefore, the program's success is not sensitive to interest rates.

(c) Use the same equation as in question 3 above with i = 0.5% per month and varying life values.

Life, years	2	3	4	5	6	8	10	15	20
$ / CCF	0.80	0.55	0.43	0.35	0.30	0.24	0.20	0.15	0.13
$/1000 gal	1.07	0.74	0.57	0.47	0.40	0.32	0.27	0.20	0.17

For a 2-year life and an interest rate of a nominal 6% per year, compounded monthly, the cost of the program is $1.07/1000 gallons, which is very close to the savings of $1.10/1000 gallons. But the cost decreases rapidly as life increases.

If further sensitivity analysis is performed, the following results are obtained. At an interest rate of 8% per year, the costs and savings are equal. Above 8% per year, the program would not be cost effective for a 2-year toilet life at the 75% rebate level. When the rebate is increased to 100%, the cost of the program exceeds the savings at all interest rates above 4.5% per year for a toilet life of 3 years.

These calculations reveal that at very short toilet lives (2-3 years), there are some conditions under which the program will not be financially successful. Therefore, it can be concluded that the program's success is mildly sensitive to toilet life.

Chapter 6

Annual Worth Analysis

Solutions to Problems

6.1 The estimate obtained from the three-year AW would *not* be valid, because the AW calculated over one life cycle is valid only for the *entire cycle*, not part of the cycle. Here the asset would be used for only a part of its three-year life cycle.

6.2
$$-10{,}000(A/P,10\%,3) - 7000 = -10{,}000(A/P,10\%,2) - 7000 + S(A/F,10\%,2)$$
$$-10{,}000(0.40211) - 7000 = -10{,}000(0.57619) - 7000 + S(0.47619)$$
$$S = \$3656$$

6.3
$$\begin{aligned} AW_{GM} &= -26{,}000(A/P,15\%,3) - 2000 + 12{,}000(A/F,15\%,3) \\ &= -26{,}000(0.43798) - 2000 + 12{,}000(0.28798) \\ &= \$-9932 \end{aligned}$$

$$\begin{aligned} AW_{Ford} &= -29{,}000(A/P,15\%,3) - 1200 + 15{,}000(A/F,15\%,3) \\ &= -29{,}000(0.43798) - 1200 + 15{,}000(0.28798) \\ &= \$-9582 \end{aligned}$$

Purchase the Ford SUV.

6.4
$$\begin{aligned} AW_{centrifuge} &= -250{,}000(A/P,10\%,6) - 31{,}000 + 40{,}000(A/F,10,6) \\ &= -250{,}000(0.22961) - 31{,}000 + 40{,}000(0.12961) \\ &= \$-83{,}218 \end{aligned}$$

$$\begin{aligned} AW_{belt} &= -170{,}000(A/P,10\%,4) - 35{,}000 - 26{,}000(P/F,10\%,2)(A/P,10\%,4) \\ &\quad + 10{,}000(A/F,10\%,4) \\ &= -170{,}000(0.31547) - 35{,}000 - 26{,}000(0.8624)(0.31547) \\ &\quad + 10{,}000(0.21547) \\ &= \$-93{,}549 \end{aligned}$$

Select centrifuge.

6.5
$$\begin{aligned} AW_{small} &= -1{,}700{,}000(A/P,1\%,120) - 12{,}000 + 170{,}000(A/F,1\%,120) \\ &= -1{,}700{,}000(0.01435) - 12{,}000 + 170{,}000(0.00435) \\ &= \$-35{,}656 \end{aligned}$$

$$\begin{aligned} AW_{large} &= -2{,}100{,}000(A/P,1\%,120) - 8{,}000 + 210{,}000(A/F,1\%,120) \\ &= -2{,}100{,}000(0.01435) - 8{,}000 + 210{,}000(0.00435) \\ &= \$-37{,}222 \end{aligned}$$

Select small pipeline.

6.6 $AW_A = -2{,}000{,}000(A/P,1\%,36) – 5000 + 200{,}000(A/F,1\%,36)$
$= -2{,}000{,}000(0.03321) – 5000 + 200{,}000(0.02321)$
$= \$-66{,}778$

$AW_B = -25{,}000(A/P,1\%,36) – 45{,}000(P/A,1\%,8)(A/P,1\%,36)$
$- 10{,}000(P/A,1\%,28)(P/F,1\%,8)(A/P,1\%,36)$
$= -25{,}000(0.03321) – 45{,}000(7.6517)(0.03321)$
$- 10{,}000(24.3164)(0.9235)(0.03321)$
$= \$-19{,}723$

Select plan B.

6.7 $AW_X = -85{,}000(A/P,12\%,3) – 30{,}000 + 40{,}000(A/F,12\%,3)$
$= -85{,}000(0.41635) – 30{,}000 + 40{,}000(0.29635)$
$= \$-53{,}536$

$AW_Y = -97{,}000(A/P,12\%,3) – 27{,}000 + 48{,}000(A/F,12\%,3)$
$= -97{,}000(0.41635) – 27{,}000 + 48{,}000(0.29635)$
$= \$-53{,}161$

Select robot Y by a small margin.

6.8 $AW_A = -25{,}000(A/P,12\%,2) – 4000$
$= -25{,}000(0.59170) – 4{,}000$
$= \$-18{,}793$

$AW_B = -88{,}000(A/P,12\%,6) – 1400$
$= -88{,}000(0.24323) – 1400$
$= \$-22{,}804$

Select plan A.

6.9 $AW_X = -7650(A/P,12\%,2) – 1200$
$= -7650(0.59170) – 1200$
$= \$-5726.51$

$AW_Y = -12{,}900(A/P,12\%,4) – 900 + 2000(A/F,12\%,4)$
$= -12{,}900(0.32923) – 900 + 2000(0.20923)$
$= \$-4728.61$

Select plan Y.

6.10 $AW_C = -40{,}000(A/P,15\%,3) – 10{,}000 + 12{,}000(A/F,15\%,3)$
$= -40{,}000(0.43798) – 10{,}000 + 12{,}000(0.28798)$
$= \$-24{,}063$

$AW_D = -65{,}000(A/P,15\%,6) – 12{,}000 + 25{,}000(A/F,15\%,6)$
$= -65{,}000(0.26424) – 12{,}000 + 25{,}000(0.11424)$
$= \$-26{,}320$

Select machine C.

6.11 $AW_K = -160{,}000(A/P,1\%,24) – 7000 + 40{,}000(A/F,1\%,24)$
$= -160{,}000(0.04707) – 7000 + 40{,}000(0.03707)$
$= \$-13{,}048$

$AW_L = -210{,}000(A/P,1\%,48) – 5000 + 26{,}000(A/F,1\%,48)$
$= -210{,}000(0.02633) – 5000 + 26{,}000(0.01633)$
$= \$-10{,}105$

Select process L.

6.12 $AW_Q = -42{,}000(A/P,10\%,2) – 6000$
$= -42{,}000(0.57619) – 6000$
$= \$-30{,}200$

$AW_R = -80{,}000(A/P,10\%,4) – [7000 + 1000(A/G,10\%,4)] + 4000(A/F,10\%,4)$
$= -80{,}000(0.31547) – [7000 + 1000(1.3812)] + 4000(0.21547)$
$= \$-32{,}757$

Select project Q.

6.13 $AW_{land} = -110{,}000(A/P,12\%,3) –95{,}000 + 15{,}000(A/F,12\%,3)$
$= -110{,}000(0.41635) –95{,}000 + 15{,}000(0.29635)$
$= \$-136{,}353$

$AW_{incin} = -800{,}000(A/P,12\%,6) –60{,}000 + 250{,}000(A/F,12\%,6)$
$= -800{,}000(0.24323) –60{,}000 + 250{,}000(0.12323)$
$= \$-223{,}777$

$AW_{contract} = \$-190{,}000$

Use land application.

6.14 $AW_{hot} = -[(700)(300) + 24{,}000](A/P,8\%,2) – 5000$
$= -234{,}000(0.56077) – 5000$
$= \$-136{,}220$

$AW_{resurface} = -850{,}000(A/P,8\%,10) – 2000(P/A,8\%,8)(P/F,8\%,2)(A/P,8\%,10)$
$= -850{,}000(0.14903) – 2000(5.7466)(0.8573)(0.14903)$
$= \$-128{,}144$

Resurface the road.

6.15 Find P in year 29, move back to year 9, and then use A/F for n = 10.

$A = [80{,}000/0.10](P/F,10\%,20)(A/F,10\%,10)$
$= [80{,}000/0.10](0.1486)(0.06275)$
$= \$\ 7459.72$

6.16 $AW_{100} = 100{,}000(A/P,10\%,100)$
$= 100{,}000(0.10001)$
$= \$10{,}001$

$AW_{\infty} = 100{,}000(0.10)$
$= \$10{,}000$

Difference is $1.

6.17 First find the value of the account in year 11 and then multiply by i = 6%.

$F_{11} = 20{,}000(F/P,15\%,11) + 40{,}000(F/P,15\%,9) + 10{,}000(F/A,15\%,8)$
$= 20{,}000(4.6524) + 40{,}000(3.5179) + 10{,}000(13.7268)$
$= \$371{,}032$

$A = 371{,}032(0.06)$
$= \$22{,}262$

6.18 $AW = 50{,}000(0.10) + 50{,}000 = \$55{,}000$

6.19 $AW = -100{,}000(0.08) –50{,}000(A/F,8\%,5)$
$= -100{,}000(0.08) –50{,}000(0.17046)$
$= \$-16{,}523$

6.20 Perpetual AW is equal to AW over one life cycle

$AW = -[6000(P/A,8\%,28) + 1000(P/G,8\%,28)](P/F,8\%,2)(A/P,8\%,30)$
$= -[6000(11.0511) + 1000(97.5687)](0.8573)(0.08883)$
$= \$-12{,}480$

6.21 $P_{-1} = 1{,}000{,}000(P/A,10\%,11) + 100{,}000(P/G,10\%,11)$
$= 1{,}000{,}000(6.4951) + 100{,}000(26.3963)$
$= \$9{,}134{,}730$

Amt in yr 10 $= 9{,}134{,}730(F/P,10\%,11)$
$= 9{,}134{,}730(2.8531)$
$= \$26{,}062{,}298$

$AW = 26{,}062{,}298(0.10)$
$= \$2{,}606{,}230$

6.22 Find P in year –1, move to year 9, and then multiply by i. Amounts are in \$1000.

$P_{-1} = [100(P/A,12\%,7) – 10(P/G,12\%,7)](F/P,12\%,10)$
$= [100(4.5638) – 10(11.6443)](3.1058)$
$= \$1055.78$

$A = 1055.78(0.12)$
$= \$126.69$

6.23 (a) $AW_{\text{in-house}} = -30(A/P,15\%,10) – 5 + 14 + 7(A/F,15\%,10)$
$= -30(0.19925) – 5 + 14 + 7(0.04925)$
$= \$3.37$ (\$ millions)

$AW_{\text{license}} = -2(0.15) –0.2 + 1.5$
$= \$1.0$ (\$ millions)

$AW_{\text{contract}} = -2 + 2.5$
$= \$0.5$ (\$ millions)

Select in-house option.

(b) All three options are acceptable.

FE Review Solutions

6.24 Answer is (b)

6.25 Find PW in year 0 and then multiply by i.

$PW_0 = 50{,}000 + 10{,}000(P/A,10\%,15) + (20{,}000/0.10)(P/F,10\%,15)$
$= 50{,}000 + 10{,}000(7.6061) + (20{,}000/0.10)(0.2394)$
$= \$173{,}941$

AW = 173,941(0.10)
= $17,394

Answer is (c)

6.26 A = [40,000/0.08](P/F,8%,2)(A/F,8%,3)
= [40,000/0.08](0.8573)(0.30803)
= $132,037

Answer is (d)

6.27 A = [50,000/0.10](P/F,10%,20)(A/F,10%,10)
= [50,000/0.10](0.1486)(0.06275)
= $4662

Answer is (b)

6.28 Note: i = *effective* 10% per year.

A = [100,000(F/P,10%,5) – 10,000(F/A,10%,6)](0.10)
= [100,000(1.6105) – 10,000(7.7156)](0.10)
= $8389

Answer is (b)

6.29 i/year = $(1 + 0.10/2)^2 - 1$ = 10.25%

Answer is (d)

6.30 i/year = $(1 + 0.10/2)^2 - 1$ = 10.25%

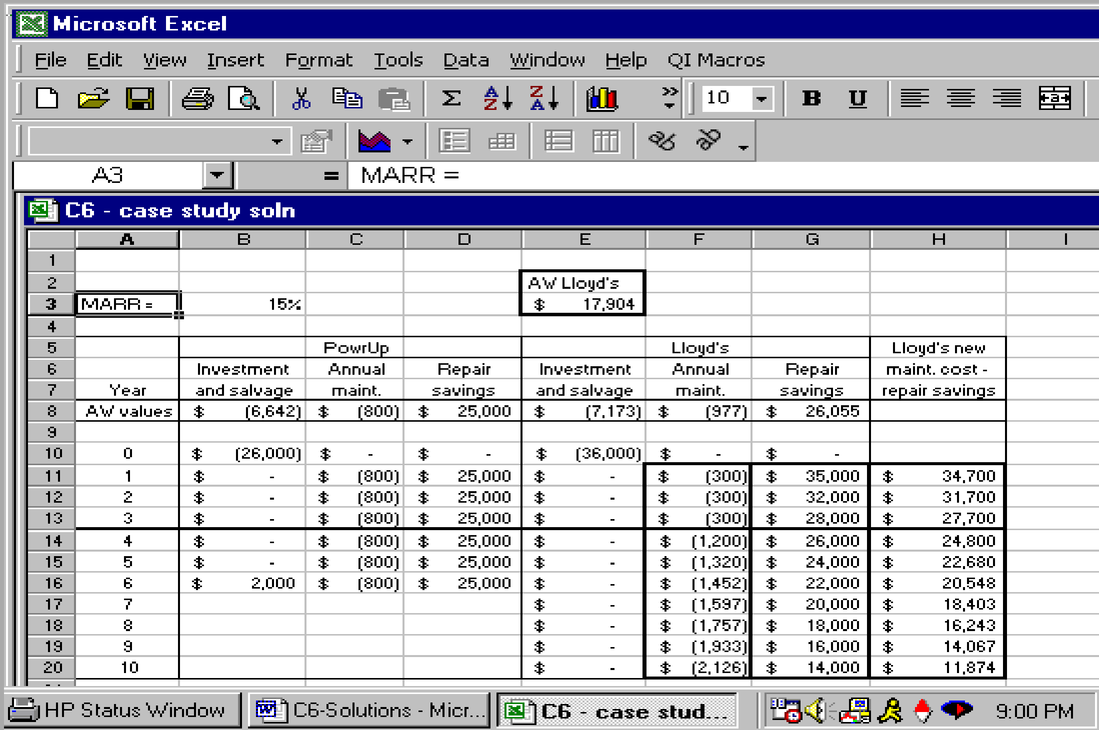
Answer is (d)

6.31 AW = -800,000(0.10) – 10,000
= $-90,000

Answer is (c)

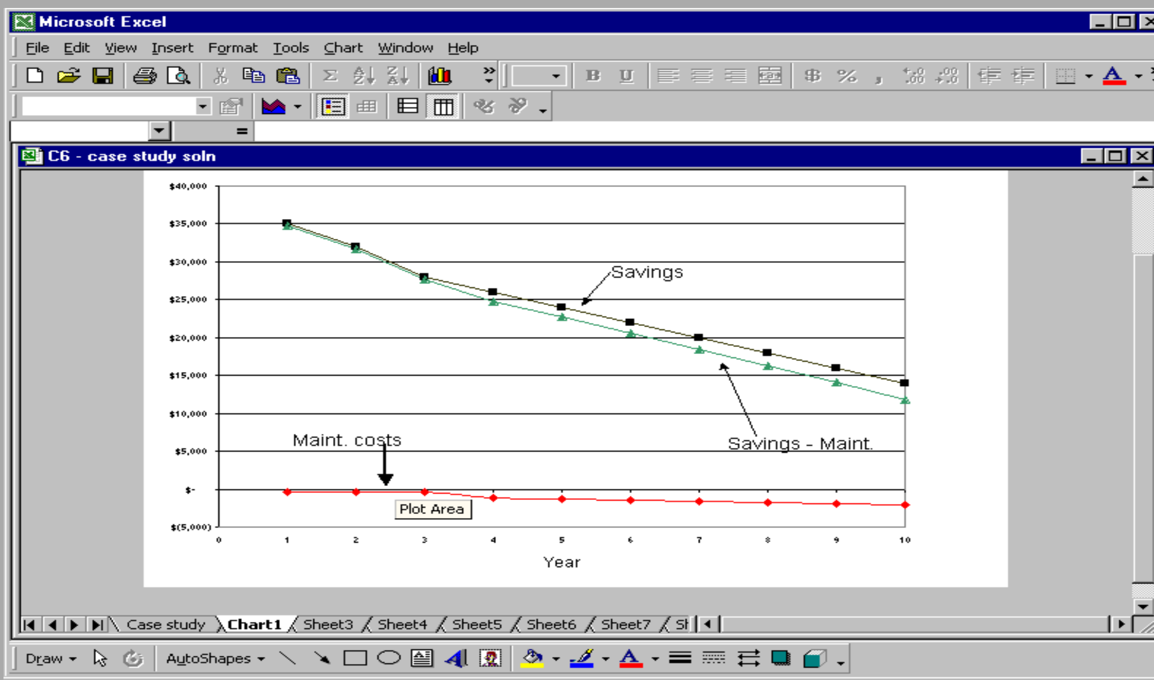
Case Study Solution

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



Microsoft Excel — C6 - case study soln — A3 = MARR =

	A	B	C	D	E	F	G	H
1								
2					AW Lloyd's			
3	MARR =	15%			$ 17,904			
4								
5			PowrUp			Lloyd's		Lloyd's new
6		Investment	Annual	Repair	Investment	Annual	Repair	maint. cost -
7	Year	and salvage	maint.	savings	and salvage	maint.	savings	repair savings
8	AW values	$ (6,642)	$ (800)	$ 25,000	$ (7,173)	$ (977)	$ 26,055	
9								
10	0	$ (26,000)	$ -	$ -	$ (36,000)	$ -	$ -	
11	1	$ -	$ (800)	$ 25,000	$ -	$ (300)	$ 35,000	$ 34,700
12	2	$ -	$ (800)	$ 25,000	$ -	$ (300)	$ 32,000	$ 31,700
13	3	$ -	$ (800)	$ 25,000	$ -	$ (300)	$ 28,000	$ 27,700
14	4	$ -	$ (800)	$ 25,000	$ -	$ (1,200)	$ 26,000	$ 24,800
15	5	$ -	$ (800)	$ 25,000	$ -	$ (1,320)	$ 24,000	$ 22,680
16	6	$ 2,000	$ (800)	$ 25,000	$ -	$ (1,452)	$ 22,000	$ 20,548
17	7				$ -	$ (1,597)	$ 20,000	$ 18,403
18	8				$ -	$ (1,757)	$ 18,000	$ 16,243
19	9				$ -	$ (1,933)	$ 16,000	$ 14,067
20	10				$ -	$ (2,126)	$ 14,000	$ 11,874



2. In cell E3, the new AW = $17,904. This is only slightly larger than the PowrUp AW = $17,558. Marginally select Lloyd's.

3. New CR = $-7173, which is an increase from the $-7025 previously displayed in cell E8.

Chapter 7

Rate of Return Analysis: Single Alternative

Solutions to Problems

7.1 A rate of return of –100% means that the entire investment is lost.

7.2 Balance = 10,000(1.50) – 5(2638)
= \$1810

7.3 (a) Annual payment = [10,000/4 + 10,000(0.10)]
= \$3500

(b) A = 10,000(A/P,10%,4)
= 10,000(0.31547)
= \$3154.70

7.4 Monthly pmt = 100,000(A/P,0.5%,360)
= 100,000(0.00600)
= \$600

Balloon pmt = 100,000(F/P,0.5%,60) – 600(F/A,0.5%,60)
= 100,000(1.3489) – 600(69.7700)
= \$93,028

7.5 0 = -150,000 + (33,000 – 27,000)(P/A,i,30)
(P/A,i,30) = 25.0000
i = 1.2% per month (interpolation or Excel)

7.6 0 = -400,000 + [(10(200) + 25(50) +70(100)](P/A,i%,48)
(P/A,i%,48) = 39.0240

Solve by trial and error or Excel
i = 0.88% per month (Excel)

7.7 0 = -30,000 + (27,000 – 18,000)(P/A,i%,5) + 4000(P/F,i%,5)

Solve by trial and error or Excel
i = 17.9 % (Excel)

7.8 $0 = -130{,}000 - 49{,}000(P/A,i\%,8) + 78{,}000(P/A,i\%,8) + 1000(P/G,i\%,8)$
$+ 23{,}000(P/F,i\%,8)$

Solve by trial and error or Excel
$i = 19.2\%$ (Excel)

7.9 $(100{,}000 - 10{,}000)i = 10{,}000$
$i = 11.1\%$

7.10 $0 = -10 - 4(P/A,i\%,3) - 3(P/A,i\%,3)(P/F,i\%,3) + 2(P/F,i\%,1) + 3(P/F,i\%,2)$
$+ 9(P/A,i\%,4)(P/F,i\%,2)$

Solve by trial and error or Excel
$i = 14.6\%$ (Excel)

7.11(a) $0 = -(220{,}000 + 15{,}000 + 76{,}000)(A/P,i\%,36) + 12{,}000(2.00 - 1.05) + 2000$
$+ 100{,}000(A/F,i\%,36)$
$0 = -(311{,}000)(A/P,i\%,36) + 13{,}400 + 100{,}000(A/F,i\%,36)$

Solve by trial and error or Excel
$i = 3.3\%$ per month (Excel)

(b) Nominal per year = 3.3(12)
= 39.6% per year

Effective per year = $(1 + 0.396/12)^{12} - 1$
= 47.6% per year

7.12 $0 = -40 - 28(P/A, i\%,3) + 5(P/F,i\%,4) + 15(P/F,i\%,5) + 30(P/A,i\%,5)(P/F,i\%,5$

Solve by trial and error or Excel
$i = 5.2\%$ per year (Excel)

7.13 (a) $0 = -41{,}000{,}000 + 55{,}000(60)(P/A,i\%,30)$

Solve by trial and error or Excel
$i = 7.0\%$ per year (Excel)

(b) $0 = -41{,}000{,}000 + [55{,}000(60) + 12{,}000(90)](P/A,i\%,30)$
$0 = -41{,}000{,}000 + (4{,}380{,}000)(P/A,i\%,30)$

Solve by trial and error or Excel
$i = 10.1\%$ per year (Excel)

7.14 Cash flow tabulation is below. Note that both series *end* at the end of month 11.

Month	M3Turbo	M3Power	Difference
0	-7.99	-(14.99 + 10.99)	-17.99
1	-7.99	0	+7.99
2	-7.99	-10.99	- 3.00
3	-7.99	0	+ 7.99
4	-7.99	-10.99	- 3.00
5	-7.99	0	+7.99
6	-7.99	-10.99	-3.00
7	-7.99	0	+7.99
8	-7.99	-10.99	-3.00
9	-7.99	0	+7.99
10	-7.99	-10.99	- 3.00
11	-7.99	0	+7.99

(a) 0 = -17.99 + 7.99(P/F,i%,1) – 3.00(P/F,i%,2) + 7.99(P/F,i%,3) – 3.00(P/F,i%,4)
+ ... + 7.99(P/F,i%,9) – 3.00(P/F,i%,10) + 7.99(P/F,i%,11)

Solve by trial and error or Excel
i = 12.2% per month (Excel)

(b) Nominal per year = 12.2(12) = 146.4% per year

Effective = $(1 + 0.122)^{12} – 1$
= 298% per year

7.15 0 = -90,000(A/P,i%,24) – 0.014(6000) + 0.015(6000)(150)
0 = -90,000(A/P,i%,24) + 13,416

Solve by trial and error or Excel
i = 14.3% per month (Excel)

7.16 0 = -110,000 + 4800(P/A,i%,60)
(P/A,i%,60) = 22.9167

Use tables or Excel
i = 3.93% per month (Excel)

7.17 0 = -210 – 150(P/F,i%,1) + [100(P/A,i%,4) + 60(P/G,i%,4)](P/F,i%,1)

Solve by trial and error or Excel
i = 24.7% per year (Excel)

7.18 $0 = -450{,}000 – [50{,}000(P/A,i\%,5) –10{,}000(P/G,i\%,5)] + 10{,}000(P/A,i\%,5) +10{,}000(P/G,i\%,5) + 80{,}000(P/A,i\%,7)(P/F,i\%,5)$

Solve by trial and error or Excel
i = 2.36% per quarter (Excel)
= 2.36(4)
= 9.44% per year (nominal)

7.19 $0 = -950{,}000 + [450{,}000(P/A,i\%,5) + 50{,}000(P/G,i\%,5)])(P/F,i\%,10)$

Solve by trial and error or Excel
i = 8.45% per year (Excel)

7.20 $10{,}000{,}000(F/P,i\%,4)(i) = 100(10{,}000)$
Solve by trial and error
i = 7.49%

7.21 $[(5{,}000{,}000 – 200{,}000)(F/P, i\%,5) – 200{,}000(F/A,i\%,5)](i) = 1{,}000{,}000$
Solve by trial and error
i = 13.2%

7.22 In a conventional cash flow series, there is only one sign change in the *net cash flow.* A nonconventional series has more than one sign change.

7.23 Descartes' rule uses *net cash flows* while Norstrom's criterion is based on *cumulative cash flows*.

7.24 (a) three; (b) one; (c) five

7.25 Tabulate net cash flows and cumulative cash flows.

Quarter	Expenses	Revenue	Net Cash Flow	Cumulative
0	-20	0	-20	-20
1	-20	5	-15	-35
2	-10	10	0	-35
3	-10	25	15	-20
4	-10	26	16	-4
5	-10	20	10	+6
6	-15	17	2	+8
7	-12	15	3	+11
8	-15	2	-13	-2

(a) From net cash flow column, there are two possible i* values

(b) In cumulative cash flow column, sign starts negative but it changes twice. Therefore, Norstrom's criterion is not satisfied. Thus, there may be up to two i* values. However, in this case, since the cumulative cash flow is negative, there is no positive rate of return value.

7.26 (a) There are two sign changes, indicating that there may be two real-number rate of return values.

(b) 0 = -30,000 + 20,000(P/F,i%,1) + 15,000(P/F,i%,2) - 2000(P/F,i%,3)
Solve by trial and error or Excel
i = 7.43% per year (Excel)

7.27 (a) There are three sign changes, Therefore, there are three possible i* values.

(b) 0 = -17,000 + 20,000(P/F,i%,1) - 5000(P/F,i%,2) + 8000(P/F,i%,3)
Solve by trial and error or Excel
i = 24.4% per year (Excel)

7.28 The net cash flow and cumulative cash flow are shown below.

Year	Expenses, $	Savings, $	Net Cash Flow, $	Cumulative, $
0	-33,000	0	-33,000	-33,000
1	-15,000	18,000	+3,000	-30,000
2	-40,000	38,000	-2000	-32,000
3	-20,000	55,000	+35,000	+3000
4	-13,000	12,000	-1000	+2000

(a) There are four sign changes in net cash flow, so, there are four possible i* values.

(b) Cumulative cash flow starts negative and changes only once. Therefore, there is only one positive, real solution.

0 = -33,000 + 3000(P/F,i%,1) - 2000(P/F,i%,2) + 35,000(P/F,i%,3)
-1000(P/F,i%,4)
Solve by trial and error or Excel
i = 2.1% per year (Excel)

7.29 Cumulative cash flow starts negative and changes only once, so, there is only one positive real solution.

0 = -5000 + 4000(P/F,i%,) + 20,000(P/F,i%,4) - 15,000(P/F,i%,5)

Solve by trial and error or Excel
i = 44.1% per year (Excel)

7.30 Reinvestment rate refers to the interest rate that is used for funds that are released from a project before the project is over.

7.31 Tabulate net cash flow and cumulative cash flow values.

Year	Cash Flow, $	Cumulative, $
1	-5000	-5,000
2	-5000	-10,000
3	-5000	-15,000
4	-5000	-20,000
5	-5000	-25,000
6	-5000	-30,000
7	+9000	-21,000
8	-5000	-26,000
9	-5000	-31,000
10	-5000 + 50,000	+14,000

(a) There are three changes in sign in the net cash flow series, so there are three possible ROR values. However, according to Norstrom's criterion regarding cumulative cash flow, there is only one ROR value.

(b) Move all cash flows to year 10.

$$0 = -5000(F/A,i,10) + 14,000(F/P,i,3) + 50,000$$

Solve for i by trial and error or Excel

$i = 6.3\%$ (Excel)

(c) If Equation [7.6] is applied, all F values are negative except the last one. Therefore, i' is used in all equations. The composite ROR (i') is the same as the internal ROR value (i*) of 6.3% per year.

7.32 First, calculate the cumulative CF.

Year	Cash Flow, $1000	Cumulative CF, $1000
0	-65	-65
1	30	-35
2	84	+49
3	-10	+39
4	-12	+27

(a) The cumulative cash flow starts out negatively and changes sign only once, indicating there is only one root to the equation.

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

Solve for i by trial and error or Excel.

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

(b) Apply net reinvestment procedure because reinvestment rate, c, is not equal to i* rate of 28.6% per year:

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

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 (Excel)

7.33 Apply net reinvestment procedure.

$F_0 = 3000$ $F_0 > 0$; use c
$F_1 = 3000(1 + 0.14) - 2000$
$= 1420$ $F_1 > 0$; use c
$F_2 = 1420(1 + 0.14) + 1000$
$= 2618.80$ $F_2 > 0$; use c
$F_3 = 2618.80(1 + 0.14) – 6000$
$= -3014.57$ $F_3 < 0$; use i’
$F_4 = -3014.57(1 + i’) + 3800$

Set $F_4 = 0$ and solve for i'.

$0 = -3014.57(1 + i') + 3800$

$i' = 26.1\%$

7.34 Apply net reinvestment procedure because reinvestment rate, c, is not equal to i* rate of 44.1% per year (from problem 7.29):

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

$F_1 = -5000(1 + i') + 4000$

$= -5000 – 5000i' + 4000$

$= -1000 – 5000i'$ $\quad$ $F_1 < 0$; use i'

$F_2 = (-1000 – 5000i')(1 + i')$

$= -1000 – 5000i' –1000i' – 5000i'^2$

$= -1000 – 6000i' – 5000i'^2$ $\quad$ $F_2 < 0$; use i'

$F_3 = (-1000 – 6000i' – 5000i'^2)(1 + i')$

$= -1000 – 6000i' – 5000i'^2 –1000i' – 6000'i^2 – 5000i'^3$

$= -1000 – 7000i' – 11{,}000i'^2 – 5000i'^3$ $\quad$ $F_3 < 0$; use i'

$F_4 = (-1000 – 7000i' – 11{,}000i'^2 – 5000i'^3)(1 + i') + 20{,}000$

$= 19{,}000 – 8000i' – 18{,}000i'^2 – 16{,}000i'^3 - 5{,}000i'^4$ $\quad$ $F_4 > 0$; use c

$F_5 = (19{,}000 – 8000i' – 18{,}000i'^2 – 16{,}000i'^3 - 5{,}000i'^4)(1.15) – 15{,}000$

$= 6850 – 9200i' – 20{,}700i'^2 – 18{,}400i'^3 - 5{,}750i'^4$

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

i' = 35.7% per year

7.35 (a) i = 25,000(0.06)/2

= $750 every six months

(b) The bond is due in 22 years, so, n = 22(2) = 44

7.36 i = 10,000(0.08)/4

= $200 per quarter

0 = -9200 + 200(P/A,i%,28) + 10,000(P/F,i%,28)

Solve for i by trial and error or Excel

i = 2.4% per quarter (Excel)

Nominal i/yr = 2.4(4) = 9.6% per year

7.37 (a) $i = 5{,}000{,}000(0.06)/4 = \$75{,}000$ per quarter

After brokerage fees, the City got $4,500,000. However, *before* brokerage fees, the ROR equation from the City's standpoint is:

$$0 = 4{,}600{,}000 – 75{,}000(P/A,i\%,120) - 5{,}000{,}000(P/F,i\%,120)$$

Solve for i by trial and error or Excel

$i = 1.65\%$ per quarter (Excel)

(b) Nominal i per year = 1.65(4)
= 6.6% per year

Effective i per year = $(1 + 0.066/4)^4 –1$
= 6.77% per year

7.38 $i = 5000(0.04)/2$
= $100 per six months

$$0 = -4100 + 100(P/A,i\%,22) + 5{,}000(P/F,i\%,22)$$

Solve for i by trial and error or Excel

$i = 3.15\%$ per six months (Excel)

7.39 $$0 = -9250 + 50{,}000(P/F,i\%,18)$$
$(P/F,i\%,18) = 0.1850$

Solve directly or use Excel

$i = 9.83\%$ per year (Excel)

7.40 $i = 5000(0.10)/2$
= $250 per six months

$$0 = -5000 + 250(P/A,i\%,8) + 5{,}500(P/F,i\%,8)$$

Solve for i by trial and error or Excel

$i = 6.0\%$ per six months (Excel)

7.41 (a) $i = 10,000,000(0.12)/4$
$= \$300,000$ per quarter

By spending \$11 million, the company will save \$300,000 every three months for 25 years and will save \$10,000,000 at that time. The ROR will be:

$0 = -11,000,000 + 300,000(P/A,i\%,100) + 10,000,000(P/F,i\%,100)$
$i = 2.71\%$ per quarter (Excel)

(b) Nominal i per year = 2.71(4)
= 10.84% per year

FE Review Solutions

7.42 Answer is (d)

7.43 Answer is (c)

7.44 $0 = 1,000,000 – 20,000(P/A,i,24) – 1,000,000(P/F,i,24)$
Solve for i by trial and error or Excel
$i = 2\%$ per month (Excel)
Answer is (b)

7.45 Answer is (b)

7.46 $0 = -60,000 + 10,000(P/A,i,10)$
$(P/A,i,10) = 6.0000$

From tables, i is between 10% and 11%
Answer is (a)

7.47 Answer is (c)

7.48 $0 = -50,000 + (7500 – 5000)(P/A,i,24) + 11,000(P/F,i,24)$

Solve for i by trial and error or Excel
$i = 2.6\%$ per month (Excel)
Answer is (a)

7.49 $0 = -100,000 + (10,000/i) (P/F,i,4)$
Solve for i by trial and error or Excel
i = 9.99%% per year (Excel)
Answer is (a)

7.50 i = 4500/50,000
= 9% per year
Answer is (c)

7.51 Answer is (d)

7.52 250 = (10,000)(b)/2
b = 5% per year payable semiannually
Answer is (c)

7.53 Since the bond is purchased for its face value, the interest rate received by the purchaser is the bond interest rate of 8% per year payable quarterly. This is a nominal interest rate per year. The effective rate per quarter is 2%
Answer is (a)

7.54 Answer is (a)

7.55 Since the bond was purchased for its face value, the interest rate received by the purchaser is the bond interest rate of 10% per year payable quarterly. Answers (a) and (b) are correct. Therefore, the best answer is (c).

Extended Exercise 1 Solution

Solution by hand

1. Charles' payment = 5000(A/P,10%,3)
= 5000(0.402115) (by formula)
= $2010.57

Year (1)	Beginning unrecovered balance (2)	Interest (3) = 0.1(2)	Total amount owed (4)=(2)+(3)	Payment (5)	Ending unrecovered balance (6)=(4)+(5)
0			$-5000.00		$-5000.00
1	$-5000.00	$-500.00	-5500.00	$2010.57	-3489.43
2	-3489.43	-348.94	-3838.37	2010.57	-1827.80
3	-1827.80	-182.78	-2010.58	2010.57	-0.01*
		$-1031.72		$6031.71	

*round-off

Jeremy's payment = $2166.67

Year (1)	Beginning unrecovered balance (2)	Interest (3) = 0.1(5000)	Total amount owed (4)=(2)+(3)	Payment (5)	Ending unrecovered balance (6)=(4)+(5)
0			$-5000.00		$-5000.00
1	$-5000.00	$-500	-5500.00	$2166.67	-3333.33
2	-3333.33	-500	-3833.33	2166.67	-1666.67
3	-1666.67	-500	-2166.67	2166.67	0.00
		$-1500		$6500.01	

Plot year versus column (4) in the form of Figure 7–1 in the text.

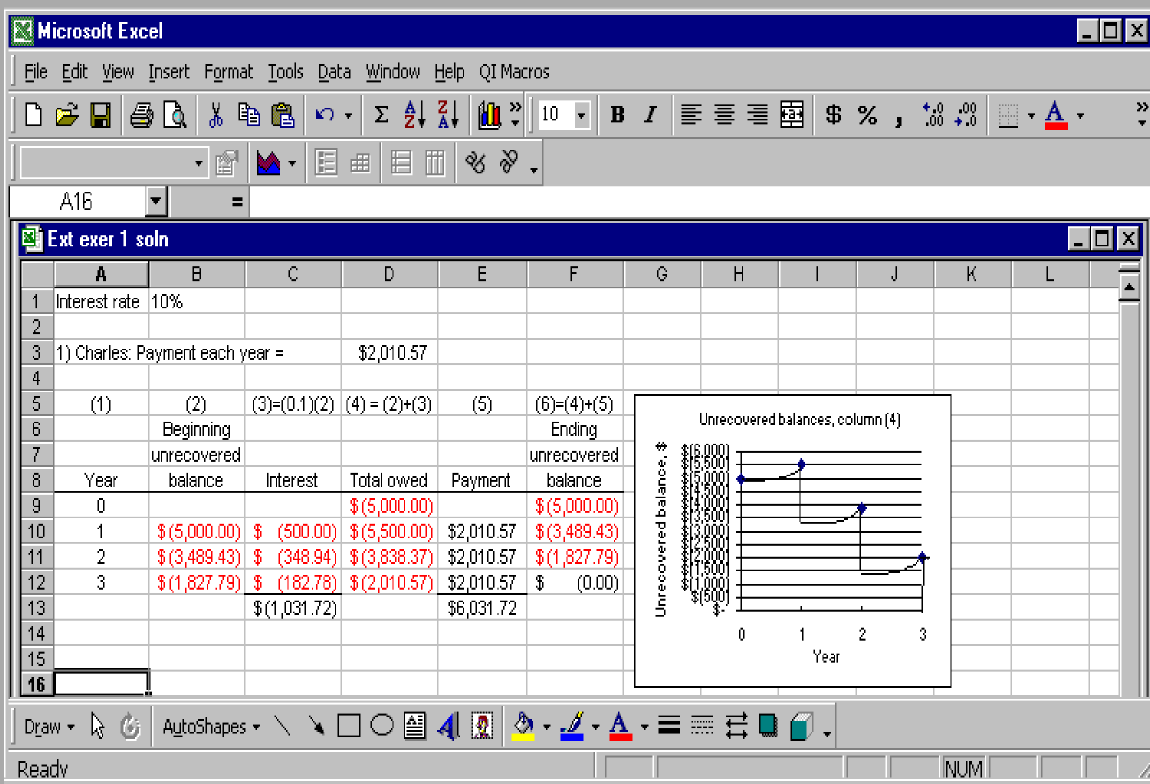
2.

	Jeremy	Charles	More for Jeremy
Interest	$1500.00	$1031.72	$468.28
Total	6500.01	6031.71	468.30

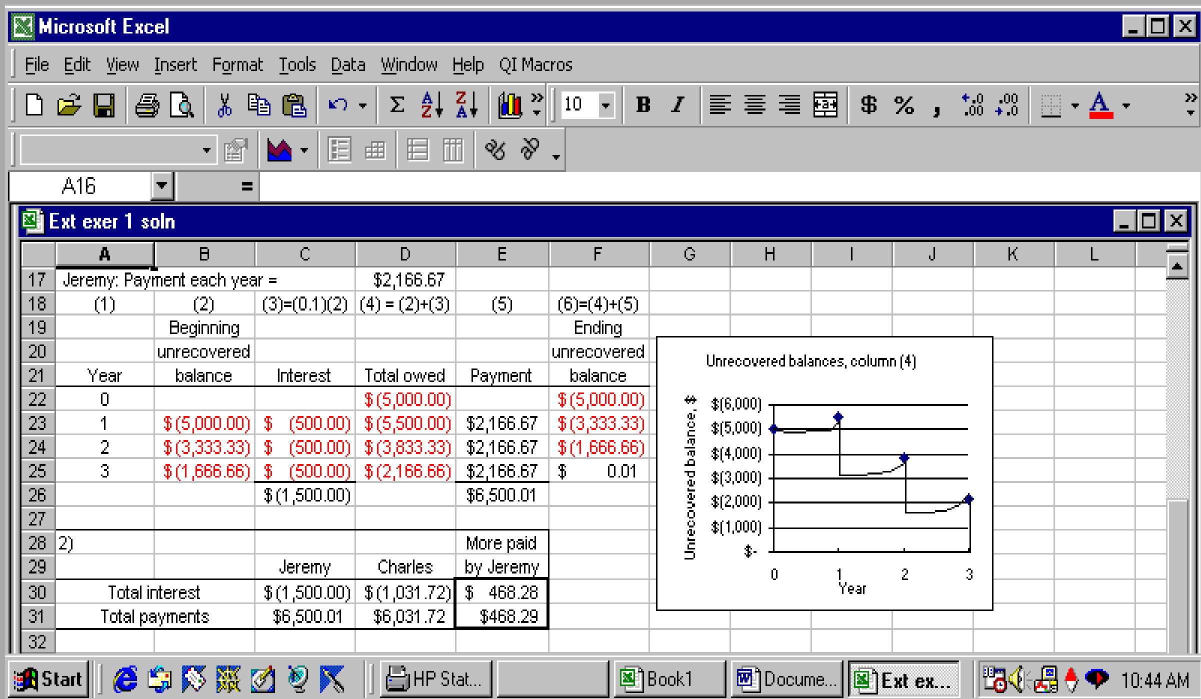
Solution by computer

1. The following spreadsheets have the same information as the two tables above. The x-y scatter charts are year (column A) versus total owed (column B). (The indicator lines and curves were drawn separately.)

2. The second spreadsheet shows that $468.28 more is paid by Jeremy.

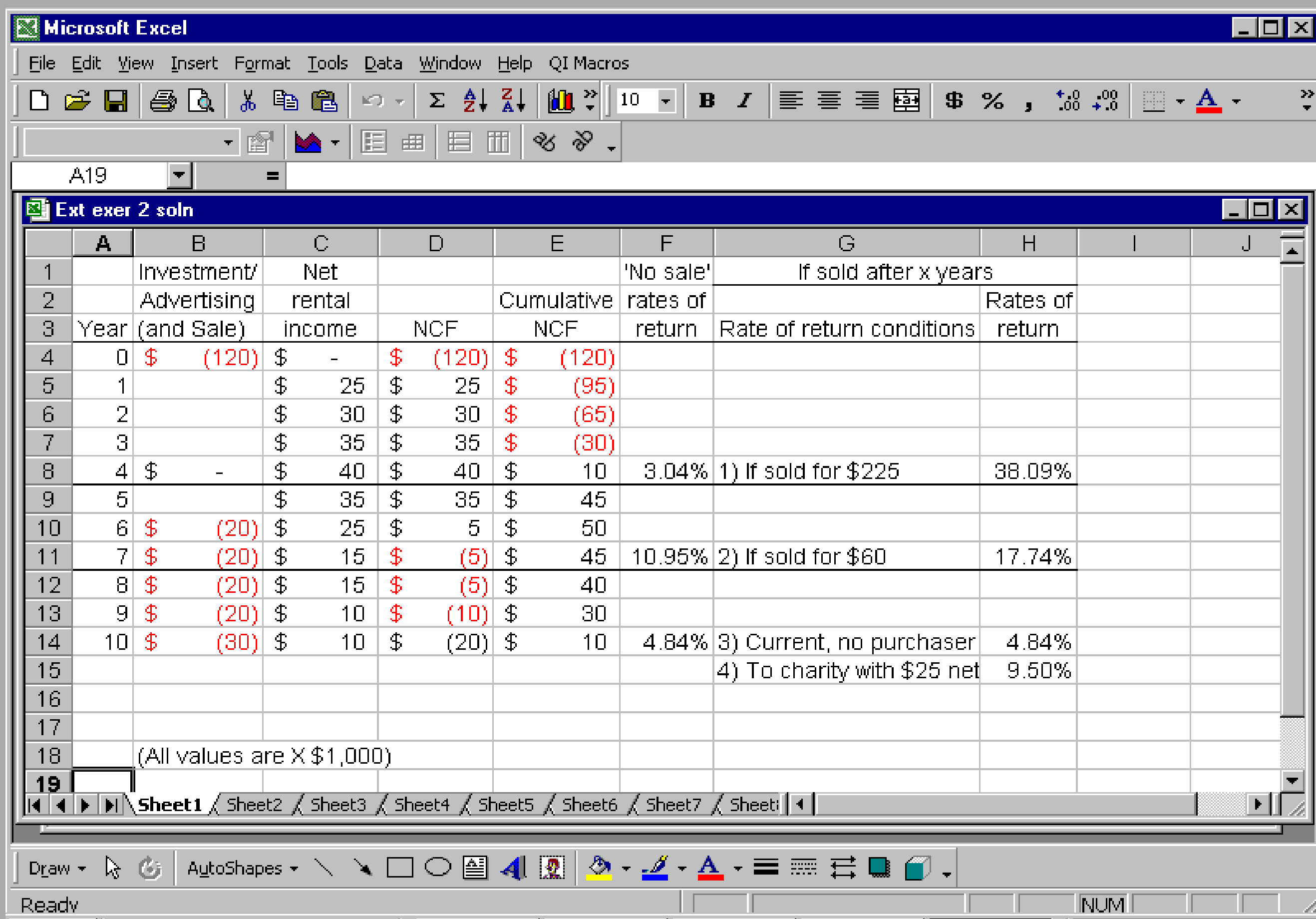


	A	B	C	D	E	F
1	Interest rate	10%				
2						
3	1) Charles: Payment each year =			$2,010.57		
4						
5	(1)	(2)	(3)=(0.1)(2)	(4) = (2)+(3)	(5)	(6)=(4)+(5)
6		Beginning				Ending
7		unrecovered				unrecovered
8	Year	balance	Interest	Total owed	Payment	balance
9	0			$(5,000.00)		$(5,000.00)
10	1	$(5,000.00)	$ (500.00)	$(5,500.00)	$2,010.57	$(3,489.43)
11	2	$(3,489.43)	$ (348.94)	$(3,838.37)	$2,010.57	$(1,827.79)
12	3	$(1,827.79)	$ (182.78)	$(2,010.57)	$2,010.57	$ (0.00)
13			$(1,031.72)		$6,031.72	
14						
15						
16						



	A	B	C	D	E	F
17	Jeremy: Payment each year =			$2,166.67		
18	(1)	(2)	(3)=(0.1)(2)	(4) = (2)+(3)	(5)	(6)=(4)+(5)
19		Beginning				Ending
20		unrecovered				unrecovered
21	Year	balance	Interest	Total owed	Payment	balance
22	0			$(5,000.00)		$(5,000.00)
23	1	$(5,000.00)	$ (500.00)	$(5,500.00)	$2,166.67	$(3,333.33)
24	2	$(3,333.33)	$ (500.00)	$(3,833.33)	$2,166.67	$(1,666.66)
25	3	$(1,666.66)	$ (500.00)	$(2,166.66)	$2,166.67	$ 0.01
26			$(1,500.00)		$6,500.01	
27						
28	2)				More paid	
29			Jeremy	Charles	by Jeremy	
30	Total interest		$(1,500.00)	$(1,031.72)	$ 468.28	
31	Total payments		$6,500.01	$6,031.72	$468.29	

Extended Exercise 2 Solution



	A	B	C	D	E	F	G	H
1		Investment/	Net			'No sale'	If sold after x years	
2		Advertising	rental		Cumulative	rates of		Rates of
3	Year	(and Sale)	income	NCF	NCF	return	Rate of return conditions	return
4	0	$ (120)	$ -	$ (120)	$ (120)			
5	1		$ 25	$ 25	$ (95)			
6	2		$ 30	$ 30	$ (65)			
7	3		$ 35	$ 35	$ (30)			
8	4	$ -	$ 40	$ 40	$ 10	3.04%	1) If sold for $225	38.09%
9	5		$ 35	$ 35	$ 45			
10	6	$ (20)	$ 25	$ 5	$ 50			
11	7	$ (20)	$ 15	$ (5)	$ 45	10.95%	2) If sold for $60	17.74%
12	8	$ (20)	$ 15	$ (5)	$ 40			
13	9	$ (20)	$ 10	$ (10)	$ 30			
14	10	$ (30)	$ 10	$ (20)	$ 10	4.84%	3) Current, no purchaser	4.84%
15							4) To charity with $25 net	9.50%
16								
17								
18		(All values are X $1,000)						

The spreadsheet above summarizes all answers in $1000. Some cells must be changed to obtain the rate of return values shown in column H. These are described below.

1. Use IRR function in year 4 and add $225 in cell C8 for year 4.

   i* (sell after 4) = 38.09%

   With no sale, IRR results in:

   i* (no sale after 4) = 3.04%

2. Use IRR function with $60 added into cell C11 for year 7.

   i* (sell after 7) = 17.74%

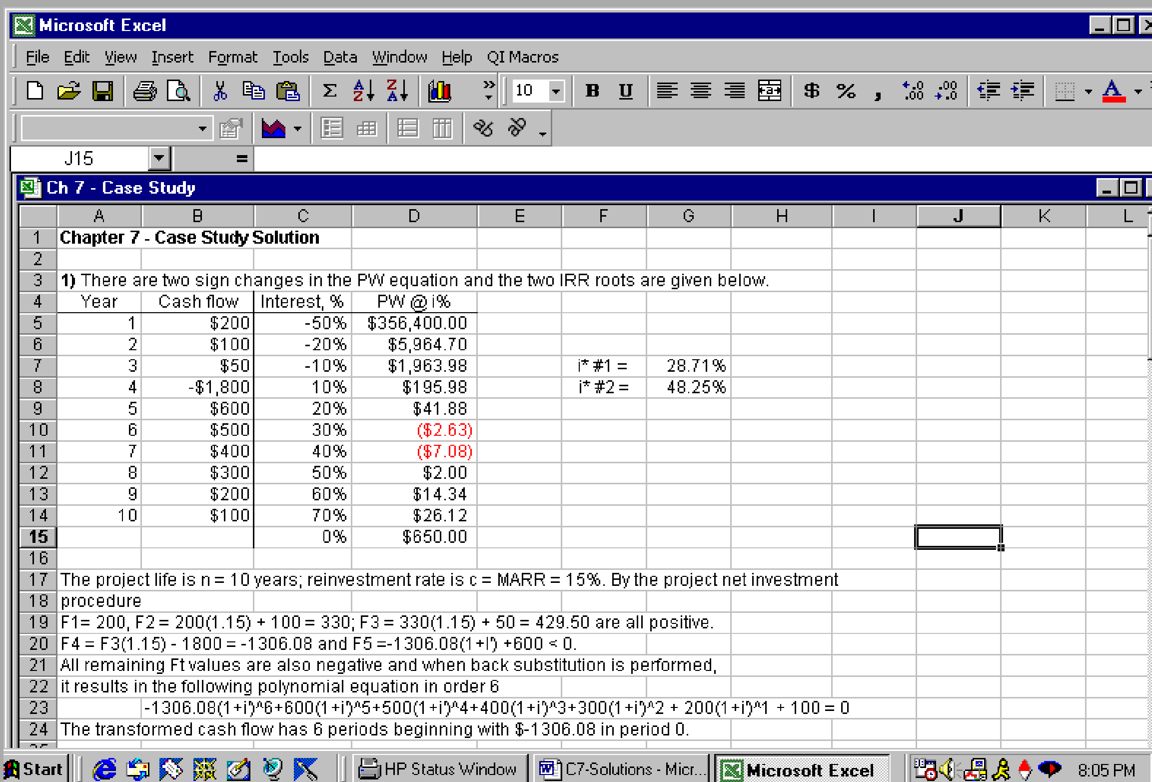
   i* (no sale after 7) = 10.95

3. i* (no sale after 10) = 4.84%

4. Use IRR function with $25 added into cell C14 for year 10.

   i* (charity after 10) = 9.5%

Case Study Solution



	A	B	C	D	E	F	G	H
1	**Chapter 7 - Case Study Solution**							
2								
3	1) There are two sign changes in the PW equation and the two IRR roots are given below.							
4	Year	Cash flow	Interest, %	PW @ i%				
5	1	$200	-50%	$356,400.00				
6	2	$100	-20%	$5,964.70				
7	3	$50	-10%	$1,963.98		i* #1 =	28.71%	
8	4	-$1,800	10%	$195.98		i* #2 =	48.25%	
9	5	$600	20%	$41.88				
10	6	$500	30%	($2.63)				
11	7	$400	40%	($7.08)				
12	8	$300	50%	$2.00				
13	9	$200	60%	$14.34				
14	10	$100	70%	$26.12				
15			0%	$650.00				
16								
17	The project life is n = 10 years; reinvestment rate is c = MARR = 15%. By the project net investment							
18	procedure							
19	F1= 200, F2 = 200(1.15) + 100 = 330; F3 = 330(1.15) + 50 = 429.50 are all positive.							
20	F4 = F3(1.15) - 1800 = -1306.08 and F5 =-1306.08(1+i') +600 < 0.							
21	All remaining Ft values are also negative and when back substitution is performed,							
22	it results in the following polynomial equation in order 6							
23		-1306.08(1+i')^6+600(1+i')^5+500(1+i')^4+400(1+i')^3+300(1+i')^2 + 200(1+i')^1 + 100 = 0						
24	The transformed cash flow has 6 periods beginning with $-1306.08 in period 0.							

Year	Cash flow	Interest rate	PW @ i%		
0	-1306.08	-25.00%	3683.77		
1	600	10.00%	338.66	i' =	21.24%
2	500	20.00%	31.16		
3	400	30.00%	(187.00)		
4	300	50.00%	(470.96)		
5	200	70.00%	(644.56)		
6	100	100.00%	(804.52)		

The cash flow sign test and the PW values shows that there is one real root. The composite rate is greater than c=MARR=15%, but less than the first i*, that is, 15% < i' < 28.71%. By using the IRR function, $\boxed{\text{i' = 21.24\%}}$

It is shown below that the project net-investment applied on the original cash flow yields the same answer as obtained from the transformed cash flow above.

2) Now, suppose c = 35% > i*#1 = 28.71%. The table in Section 7.5 of Blank and Tarquin suggests that the composite rate i' should be greater than 28.71%. However, the effect from i*#2 = 48.25% *may* cause the composite rate to be > 35%. Use the procedure in the case study to find a composite rate without having to solve a polynomial equation.

Step 1: It was performed above in finding the two i* roots.

Step 2: Make an initial guess of the composite rate; for example a value less than 35% or greater than 35% may be tried. Guess the composite rate of 33% and follow the project net investment procedure from t = 1 to t = 10. If F10 < 0, then the guessed value is too large. Another value is then tried and the procedure is repeated till F10 > 0. Now, interpolate to find the rate that makes F10 close to zero. This trial and error scheme is done conveniently on the spreadsheet.

Step 3:

Guessed: 0.33 — Reinv. rate, c = 0.35

t	Ft	CF, Ct
1	200.00	0
2	370.00	100
3	549.50	50
4	-1058.18	-1800
5	-807.37	600
6	-573.81	500
7	-363.16	400
8	-183.01	300
9	-43.40	200
10	41.41	100

Since the unrecovered balance is positive the guessed rate is a little too low. Try 33.5%.

Step 3 (repeated):

Guessed: 0.335

t	Ft	CF, Ct
1	200	0
2	370	100
3	549.50	50
4	-1058.18	-1800
5	-812.66	600
6	-584.91	500
7	-380.85	400
8	-208.43	300
9	-78.26	200
10	-4.48	100

The unrecovered balance is negative. Therefore, the unknown composite rate is between 33% and 33.5%. Interpolation gives 33.45%. At this rate the F10 = 0.26 which is close to 0.

Conclusion: Since i' = 33.45% is less than the MARR = 35%, the cash flow series is not justified at c=35%

Microsoft Excel - Ch 7 - Case Study

A110 = 9

3) Next, suppose c = 45% which is close to root i*#2. We know that the composite rate cannot be larger than i*#2 = 48.25%. But, can it either be smaller than, or greater than 45%? Again, use the proposed procedure. Guess i' = 44% (Step 2). The following calculation shows the steps.

Step 3:

Guessed: 0.44 Reinv. Rate, c = 0.45

t	Ft	CF, Ct
1	200	0
2	390	100
3	615.50	50
4	-907.53	-1800
5	-706.84	600
6	-517.84	500
7	-345.70	400
8	-197.80	300
9	-84.83	200
10	-22.16	100

Unrecovered balance is negative; the guessed rate is a little too high. Try 43.8%.

Step 3 (repeated):

Guessed: 0.438

t	Ft	CF, Ct
1	200	0
2	390	100
3	615.50	50
4	-907.53	-1800
5	-705.02	600
6	-513.82	500
7	-338.87	400
8	-187.30	300
9	-69.34	200
10	0.29	100

The guessed composite rate is a little too low. We can see that the unknown rate is between 44% and 43.5%. Interpolate to get i' = 43.8025% with F10 = 0.01.

Conclusion: Since i' = 43.85% is greater than the MARR = 35%, the cash flow series is justified when c = 45%.

Problem2

Microsoft Excel - Ch 7 - Case Study

H120 =

Here is a brief introduction and explantion of the underlying principle:

The extension procedure is started when the project net-investment stops with Fn = 0, where Fn is a high-order polynomial function larger than 4. It examines the sign of Fn using an initial guess of the composite rate near the given rate c and the nearest i* value. The procedure does not care how many roots of i* there might be.

Step 1. Determine the i* roots of the PW equation.

Step 2. From the given c and the two i* values closest to the c (arbitrarily called i* k-1 and i* k, k = 2, 3, ..., m), determine which of the following relations applies: If m = 2, c < i*1, then i' < i*1; If m=2, c > i*2, then i' > i*2;

But, if i* k-1 < c < i* k and m > 2, then i' can be < or > c and i* k-1 < i' < i* k.

Step 3. Guess a starting value for i' according to the situation. Try to find two values of i' such that Fn < 0 and Fn > 0.

Step 4. Interpolate or tweak the Fn until it is approximately zero. The corresponding i' is the solution.

4) Use the same procedure as in part (1) with c = 35%, then with c = 45%. Then place the Ft value in the appropriate year as the cash flow. Use the IRR function to determine i* (which will be i') for the remaining cash flows.

For c = 35%, determine F1 through F4

F1= 200; F2 = 200(1.35) + 100 = 370; F3 = 370(1.35) + 50 = 549.50

F4 = 549.50(1.35) - 1800 = -1058.18; now enter this value as the cash flow in year 4.

Year	Cash flow
0	-1058.18
1	600
2	500
3	400
4	300
5	200
6	100

i' = 33.45% Same as above.

Problem2

For c = 45%, use the same process.

F1= 200; F2 = 200(1.45) + 100 = 390; F3 = 390(1.45) + 50 = 615.50

F4 = 615.50(1.45) - 1800 = -907.53; now enter this value as the cash flow in year 4.

Year	Cash flow
0	$ (908)
1	$ 600
2	$ 500
3	$ 400
4	$ 300
5	$ 200
6	$ 100

i' = 43.80% Same as above.

5) No, because the c may be above MARR, but the i* values may all be below MARR. Then, the i' can be above the i*#2 value, but still less than the MARR. For example, if MARR is 10%, and the two i* values are 4% and 8%. If c is large, say 15%, the i' will be above 8%, but it surely can still be less than the MARR of 10%.

Kathy should not make the general conclusion. The result depends on the placement of the i values and the size and ordering of the cash flow estimates.

Chapter 8

Rate of Return Analysis: Multiple Alternatives

Solutions to Problems

8.1 (a) The rate of return on the increment has to be larger than 18%.
(b) The rate of return on the increment has to be smaller than 10%.

8.2 Overall ROR: 30,000(0.20) + 70,000(0.14) = 100,000(x)
x = 15.8%

8.3 There is *no income* associated with service alternatives. Therefore, the only way to obtain a rate of return is on the increment of investment.

8.4 The rate of return on the increment of investment is less than 0.

8.5 By switching the position of the two cash flows, the interpretation changes completely. The situation would be similar to receiving a loan in the amount of the difference between the two alternatives *if the lower cost alternative* is selected. The rate of return would represent the interest *paid* on the loan. Since it is higher than what the company would consider attractive (i.e., 15% *or less*), the loan should not be accepted. Therefore, select the alternative with the higher initial investment, A.

8.6 (a) Both processors should be selected because the rate of return on both exceeds the company's MARR.

(b) The microwave model should be selected because the rate of return on increment of investment between the two is greater than 23%.

8.7 (a) Incremental investment analysis is *not* required. Alternative X should be selected because the rate of return on the increment is known to be lower than 20%
(b) Incremental investment analysis is *not* required because only Alt Y has ROR greater than the MARR
(c) Incremental investment analysis is *not* required. Neither alternative should be selected because neither one has a ROR greater than the MARR.
(d) The ROR on the increment is less than 26%, but an incremental investment analysis *is* required to determine if the rate of return on the increment equals or exceeds the MARR of 20%
(e) Incremental investment analysis is *not* required because it is known that the ROR on the increment is greater than 22%.

8.8 Overall ROR: 100,000(i) = 30,000(0.30) + 20,000(0.25) + 50,000(0.20)
i = 24%

8.9 (a) Size of investment in Y = 50,000 – 20,000
= $30,000

(b) 30,000(i) + 20,000(0.15) = 50,000(0.40)
i = 56.7%

8.10

Year	Machine A	Machine B	B – A
0	-15,000	-25,000	-10,000
1	-1,600	-400	+1200
2	-1600	-400	+1200
3	-15,000 –1600 + 3000	-400	+13,200
4	-1600	-400	+1200
5	-1600	-400	+1200
6	+3000 –1600	+6000 – 400	+4200

8.11 The incremental cash flow equation is 0 = -65,000 + x(P/A,25%,4), where x is the difference in the operating costs of the processes.

x = 65,000/2.3616
= $27,524

Operating cost of process B = 60,000 – 27,524
= $32,476

8.12 The one with the *higher* initial investment should be selected because it yields a rate of return that is acceptable, that is, the MARR.

8.13 (a) Find rate of return on incremental cash flow.
0 = -3000 –200(P/A,i,3) + 4700(P/F,i,3)
i = 10.4% (Excel)

(b) Incremental ROR is less than MARR; select Ford.

8.14 (a) 0 = -200,000 + 50,000(P/A,i,5) + 130,000(P/F,i,5)

Solve for i by trial and error or Excel
i = 20.3% (Excel)

(b) i > MARR; select process Y.

8.15 $0 = -25{,}000 + 4000(P/A,i,6) + 26{,}000(P/F,i,3) – 39{,}000(P/F,i,4) + 40{,}000(P/F,i,6)$

Solve for i by trial and error or Excel
$i = 17.4\%$ (Excel)

$i > MARR$; select machine requiring extra investment: variable speed

8.16 $0 = -10{,}000 + 1200(P/A,i,4) + 12{,}000(P/F,i,2) + 1000(P/F,i,4)$

Solve for i by trial and error or Excel
$i = 30.3\%$ (Excel)
Select machine B.

8.17 $0 = -17{,}000 + 400(P/A,i,6) + 17{,}000(P/F,i,3) + 1700(P/F,i,6)$

Solve for i by trial and error or Excel
$i = 6.8\%$ (Excel)
Select alternative P.

8.18 $0 = -90{,}000 + 10{,}000(P/A,i,3) + 20{,}000(P/A,i,6)(P/F,i,3) + 5000(P/F,i,10)$

Solve for i by trial and error or Excel
$i = 10.5\%$ (Excel)
$i < MARR$; select alternative J.

8.19 Find P to yield exactly 50% and the take difference.
$0 = -P + 400{,}000(P/F,i,1) + 600{,}000(P/F,i,2) + 850{,}000(P/F,i,3)$
$P = 400{,}000(0.6667) + 600{,}000(0.4444) + 850{,}000(0.2963)$
$= \$785{,}175$

Difference = 900,000 – 785,175
= \$114,825

8.20 Let x = M & O costs. Perform an incremental cash flow analysis.

$0 = -75{,}000 + (-x + 50{,}000)(P/A,20\%,5) + 20{,}000(P/F,20\%,5)$
$0 = -75{,}000 + (-x + 50{,}000)(2.9906) + 20{,}000(0.4019)$
$x = \$27{,}609$

M & O cost for S = \$-27,609

8.21 $0 = -22{,}000(A/P,i,9) + 4000 + (12{,}000 - 4000)(A/F,i,9)$

Solve for i by trial and error or Excel
$i = 14.3\%$ (Excel)

$i >$ MARR; select alternative N

8.22 Find ROR for incremental cash flow over LCM of 4 years

$0 = -50{,}000(A/P,i,4) + 5000 + (40{,}000 - 5000)(P/F, i,2)(A/P, i,4) + 2000(A/F,i,4)$

Solve for i by trial and error or Excel
$i = 6.1\%$ (Excel)

$i <$ MARR; select semiautomatic machine

8.23 $0 = -62{,}000(A/P,i,24) + 4000 + (10{,}000 - 4000)(A/F,i,24)$

Solve for i by trial and error or Excel
$i = 4.2\%$ per month is $>$ MARR = 2% per month (Excel)

Select alternative Y

8.24 $0 = -40{,}000(A/P,i,10) + 8500 - 500(A/G,i,10)$

Solve for i by trial and error or Excel
$i = 10.5\%$ is $<$ MARR = 17% (Excel)

Select Z1

8.25 Find ROR on increment of investment.
$0 = -500{,}000(A/P,i,10) + 60{,}000$
$i = 3.5\% <$ MARR
Select design 1A

8.26 Develop a cash flow tabulation.

Year	Lease, $	Build, $	B – L, $
0	-108,000	-50,000 – 270,000	-212,000
1	-108,000	0	+108,000
2	-108,000	0	+108,000
3	0	+55,000 + 60,000	+115,000

$0 = -212{,}000(A/P,i,3) + 108{,}000 + (115{,}000 - 108{,}000) (A/F,i,3)$

Solve for i by trial and error or Excel

i = 25.8% < MARR (Excel)

Lease space

8.27 Select the one with the lowest initial investment cost because none of the increments were justified.

8.28 (a) A vs DN: 0 = -30,000(A/P,i,8) + 4000 + 1000(A/F,i,8)
Solve for i by trial and error or Excel
i = 2.1% (Excel)
Method A is *not* acceptable

B vs DN: 0 = - 36,000(A/P,i,8) + 5000 + 2000(A/F,i,8)
Solve for i by trial and error or Excel
i = 3.4% (Excel)
Method B is *not* acceptable

C vs DN: 0 = - 41,000(A/P,i,8) + 8000 + 500(A/F,i,8)
Solve for i by trial and error or Excel
i = 11.3% (Excel)
Method C *is* acceptable

D vs DN: 0 = - 53,000(A/P,i,8) + 10,500 - 2000(A/F,i,8)
Solve for i by trial and error or Excel
i = 11.1% (Excel)
Method D *is* acceptable

(b) A vs DN: 0 = -30,000(A/P,i,8) + 4000 + 1000(A/F,i,8)
Solve for i by trial and error or Excel
i = 2.1% (Excel)
Eliminate A

B vs DN: 0 = - 36,000(A/P,i,8) + 5000 + 2000(A/F,i,8)
Solve for i by trial and error or Excel
i = 3.4% (Excel)
Eliminate B

C vs DN: 0 = - 41,000(A/P,i,8) + 8000 + 500(A/F,i,8)
Solve for i by trial and error or Excel
i = 11.3% (Excel)
Eliminate DN

C vs D: $0 = -12{,}000(A/P,i,8) + 2{,}500 - 2500(A/F,i,8)$

Solve for i by trial and error or Excel

$i = 10.4\%$ (Excel)

Eliminate D

Select method C

8.29 Rank alternatives according to increasing initial cost: 2,1,3,5,4

1 vs 2: $0 = -3000(A/P,i,5) + 1500$

$(A/P,i,5) = 0.5000$

$i = 41.0\%$ (Excel)

Eliminate 2

3 vs1: $0 = -3500(A/P,i,5) + 1000$

$(A/P,i,5) = 0.2857$

$i = 13.2\%$ (Excel)

Eliminate 3

5 vs 1: $0 = -10{,}000(A/P,i,5) + 2500$

$(A/P,i,5) = 0.2500$

$i = 7.9\%$ (Excel)

Eliminate 5

4 vs1: $0 = -17{,}000(A/P,i,5) + 6000$

$(A/P,i,5) = 0.3529$

$i = 22.5\%$ (Excel)

Eliminate 1

Select machine 4

8.30 Alternatives are revenue alternatives. Therefore, add DN

(a) DN vs 8: $0 = -30{,}000(A/P,i,5) + (26{,}500 – 14{,}000) + 2000(A/F,i,5)$

Solve for i by trial and error or Excel

$i = 31.7\%$ (Excel)

Eliminate DN

8 vs 10: $0 = -4000(A/P,i,5) + (14{,}500 – 12{,}500) + 500(A/F,i,5)$

Solve for i by trial and error or Excel

$i = 42.4\%$ (Excel)

Eliminate 8

10 vs 15: $0 = -4000(A/P,i,5) + (15{,}500 – 14{,}500) + 500(A/F,i,5)$

Solve for i by trial and error or Excel

$i = 10.9\%$ (Excel)
Eliminate 15

10 vs 20: $0 = -14{,}000(A/P,i,5) + (19{,}500 – 14{,}500) + 1000(A/F,i,5)$
Solve for i by trial and error or Excel
$i = 24.2\%$ (Excel)
Eliminate 10

20 vs 25: $0 = -9000(A/P,i,5) + (23{,}000 – 19{,}500) + 1100(A/F,i,5)$
Solve for i by trial and error or Excel
$i = 29.0\%$ (Excel)
Eliminate 20

Purchase 25 m^3 truck

(b) For second truck, purchase truck that was eliminated next to last: 20 m^3

8.31 (a) Select all projects whose ROR > MARR of 15%. Select A, B, and C

(b) Eliminate alternatives with ROR < MARR; compare others incrementally:
Eliminate D and E
Rank survivors according to increasing first cost: B, C, A

B vs C: $i = 800/5000$
$= 16\%$ > MARR Eliminate B

C vs A: $i = 200/5000$
$= 4\%$ < MARR Eliminate A

Select project C

8.32 (a) All machines have ROR > MARR of 12% and all increments of investment have ROR > MARR. Therefore, select machine 4.

(b) Machines 2, 3, and 4 have ROR greater than 20%. Increment between 2 and 3 is justified, but not increment between 3 and 4. Therefore, select machine 3.

8.33 (a) Select A and C.
(b) Proposal A is justified. A vs B yields 1%, eliminate B; A vs C yields 7%, eliminate C; A vs D yields 10%, eliminate A. Therefore, select proposal D
(c) Proposal A is justified. A vs B yields 1%, eliminate B; A vs C yields 7%, eliminate C; A vs D yields 10%, eliminate D. Therefore, select proposal A

8.34 (a) Find ROR for each increment of investment:

E vs F: 20,000(0.20) + 10,000(i) = 30,000(0.35)
i = 65%

E vs G: 20,000(0.20) + 30,000(i) = 50,000(0.25)
i = 28.3%

E vs H: 20,000(0.20) + 60,000(i) = 80,000(0.20)
i = 20%

F vs G: 30,000(0.35) + 20,000(i) = 50,000(0.25)
i = 10%

F vs H: 30,000(0.35) + 50,000(i) = 80,000(0.20)
i = 11%

G vs H: 50,000(0.25) + 30,000(i) = 80,000(0.20)
i = 11.7%

(b) Revenue = A = Pi
E: A = 20,000(0.20) = $4000
F: A = 30,000(0.35) = $10,500
G: A = 50,000(0.25) = $12,500
H: A = 80,000(0.20) = $16,000

(c) Conduct incremental analysis using results from part (a):
E vs DN: i = 20% > MARR eliminate DN
E vs F: i = 65% > MARR eliminate E
F vs G: i = 10% < MARR eliminate G
F vs H: i = 11% < MARR eliminate H
Therefore, select Alternative F

(d) Conduct incremental analysis using results from part (a).
E vs DN: i = 20% >MARR, eliminate DN
E vs F: i = 65% > MARR, eliminate E
F vs G: i = 10% < MARR, eliminate G
F vs H: i = 11% = MARR, eliminate F

Select alternative H

(e) Conduct incremental analysis using results from part (a).
E vs DN: i = 20% > MARR, eliminate DN
E vs F: i = 65% > MARR, eliminate E
F vs G: i = 10% < MARR, eliminate G
F vs H: i = 11% < MARR, eliminate H

Select F as first alternative; compare remaining alternatives incrementally.

E vs DN: $i = 20\%$ > MARR, eliminate DN
E vs G: $i = 28.3\%$ > MARR, eliminate E
G vs H: $i = 11.7\%$ < MARR, eliminate H

Therefore, select alternatives F and G

8.35 (a) ROR for F: $10{,}000(0.25) + 15{,}000(0.20) = 25{,}000(i)$
$i = 22\%$

ROR for G: $25{,}000(0.22) + 5000(0.04) = 30{,}000(i)$
$i = 19\%$

Increment between E and G: $10{,}000(0.25) + 20{,}000(i) = 30{,}000(0.19)$
$i = 16\%$

Increment between E and H: $10{,}000(0.25) + 50{,}000(i) = 60{,}000(0.30)$
$i = 31\%$

Increment between F and H: $25{,}000(0.22) + 35{,}000(i) = 60{,}000(0.30)$
$i = 35.7\%$

Increment between G and H: $30{,}000(0.19) + 30{,}000(i) = 60{,}000(0.30)$
$i = 41\%$

(b) Select all alternatives with ROR ≥ MARR of 21%; select E, F, and H.

(c) Conduct incremental analysis using results from table and part (a).
E vs DN: $i = 25\%$ > MARR, eliminate DN
E vs F: $i = 20\%$ < MARR, eliminate F
E vs G: $i = 16\%$ < MARR, eliminate G
E vs H: $i = 31\%$ > MARR, eliminate E

Select alternative H.

FE Review Solutions

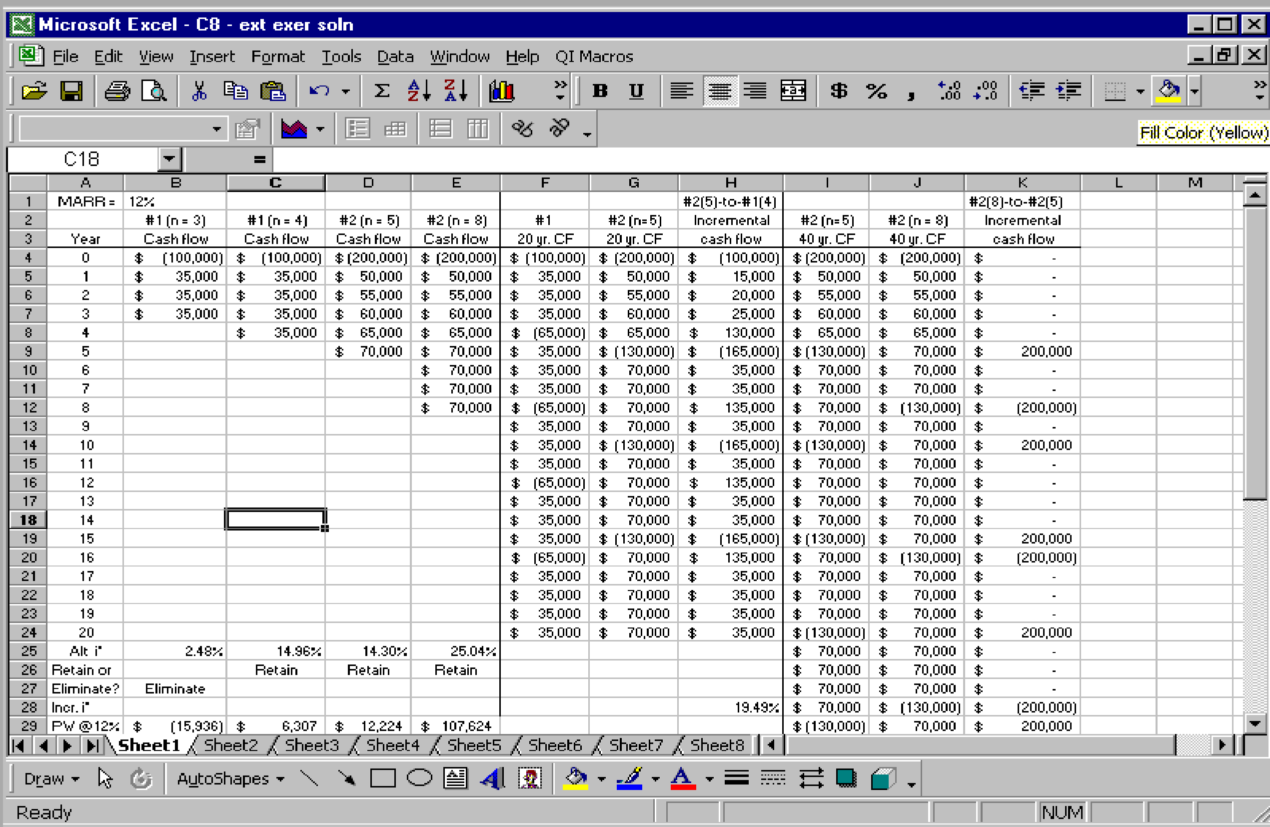
8.36 Answer is (a)
8.37 Answer is (c)
8.38 Answer is (c)
8.39 Answer is (b)
8.40 Answer is (d)

8.41 Answer is (b)
8.42 Answer is (b)
8.43 Answer is (b)

Extended Exercise Solution

1. PW at 12% is shown in row 29. Select #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 ∈i* = 19.49%. Now perform an incremental comparison of #2 for n = 5 and n = 8. This is not necessary. No extra investment is necessary to expand cash flow by three years. The ∈i* is infinity. It is obvious: select #2 (n = 8).
3. PW at 2000% > $0.05. ∈i* is infinity, as shown in cell K45, where an error for IRR(K4:K44) is indicated. This analysis is not necessary, but shows how Excel can be used over the LCM to find a rate of return.



	A	B	C	D	E	F	G	H	I	J	K
1	MARR =	12%						#2(5)-to-#1(4)			#2(8)-to-#2(5)
2		#1 (n = 3)	#1 (n = 4)	#2 (n = 5)	#2 (n = 8)	#1	#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)	$ -
5	1	$ 35,000	$ 35,000	$ 50,000	$ 50,000	$ 35,000	$ 50,000	$ 15,000	$ 50,000	$ 50,000	$ -
6	2	$ 35,000	$ 35,000	$ 55,000	$ 55,000	$ 35,000	$ 55,000	$ 20,000	$ 55,000	$ 55,000	$ -
7	3	$ 35,000	$ 35,000	$ 60,000	$ 60,000	$ 35,000	$ 60,000	$ 25,000	$ 60,000	$ 60,000	$ -
8	4		$ 35,000	$ 65,000	$ 65,000	$ (65,000)	$ 65,000	$ 130,000	$ 65,000	$ 65,000	$ -
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	$ -
11	7				$ 70,000	$ 35,000	$ 70,000	$ 35,000	$ 70,000	$ 70,000	$ -
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	$ -
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	$ -
16	12					$ (65,000)	$ 70,000	$ 135,000	$ 70,000	$ 70,000	$ -
17	13					$ 35,000	$ 70,000	$ 35,000	$ 70,000	$ 70,000	$ -
18	14					$ 35,000	$ 70,000	$ 35,000	$ 70,000	$ 70,000	$ -
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	$ -
22	18					$ 35,000	$ 70,000	$ 35,000	$ 70,000	$ 70,000	$ -
23	19					$ 35,000	$ 70,000	$ 35,000	$ 70,000	$ 70,000	$ -
24	20					$ 35,000	$ 70,000	$ 35,000	$ (130,000)	$ 70,000	$ 200,000
25	Alt i*	2.48%	14.96%	14.30%	25.04%				$ 70,000	$ 70,000	$ -
26	Retain or		Retain	Retain	Retain				$ 70,000	$ 70,000	$ -
27	Eliminate?	Eliminate							$ 70,000	$ 70,000	$ -
28	Incr. i*							19.49%	$ 70,000	$ (130,000)	$ (200,000)
29	PW @12%	$ (15,936)	$ 6,307	$ 12,224	$ 107,624				$ (130,000)	$ 70,000	$ 200,000

Microsoft Excel - ext exer 8.1 soln

	A	B	C	D	E	F	G	H	I	J	K	L	M
28	Incr. i*							19.49%	$ 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	$ -		
31	27								$ 70,000	$ 70,000	$ -		
32	28								$ 70,000	$ 70,000	$ -		
33	29								$ 70,000	$ 70,000	$ -		
34	30								$ (130,000)	$ 70,000	$ 200,000		
35	31								$ 70,000	$ 70,000	$ -		
36	32								$ 70,000	$ (130,000)	$ (200,000)		
37	33								$ 70,000	$ 70,000	$ -		
38	34								$ 70,000	$ 70,000	$ -		
39	35								$ (130,000)	$ 70,000	$ 200,000		
40	36								$ 70,000	$ 70,000	$ -		
41	37								$ 70,000	$ 70,000	$ -		
42	38			Answers					$ 70,000	$ 70,000	$ -		
43	39			1. Select #2 (n = 8)					$ 70,000	$ 70,000	$ -		
44	40			2. Select #2 (n = 8)					$ 70,000	$ 70,000	$ -		
45				3. Incremental i* is infinity		(cell K45 gives an error for IRR(K4:K44)				Incr i*	#DIV/0!		
46						and PW at large 2000% is close to zero.)				PW at 2000%	$ 0.05		
47													

Case Study 1 Solution

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.

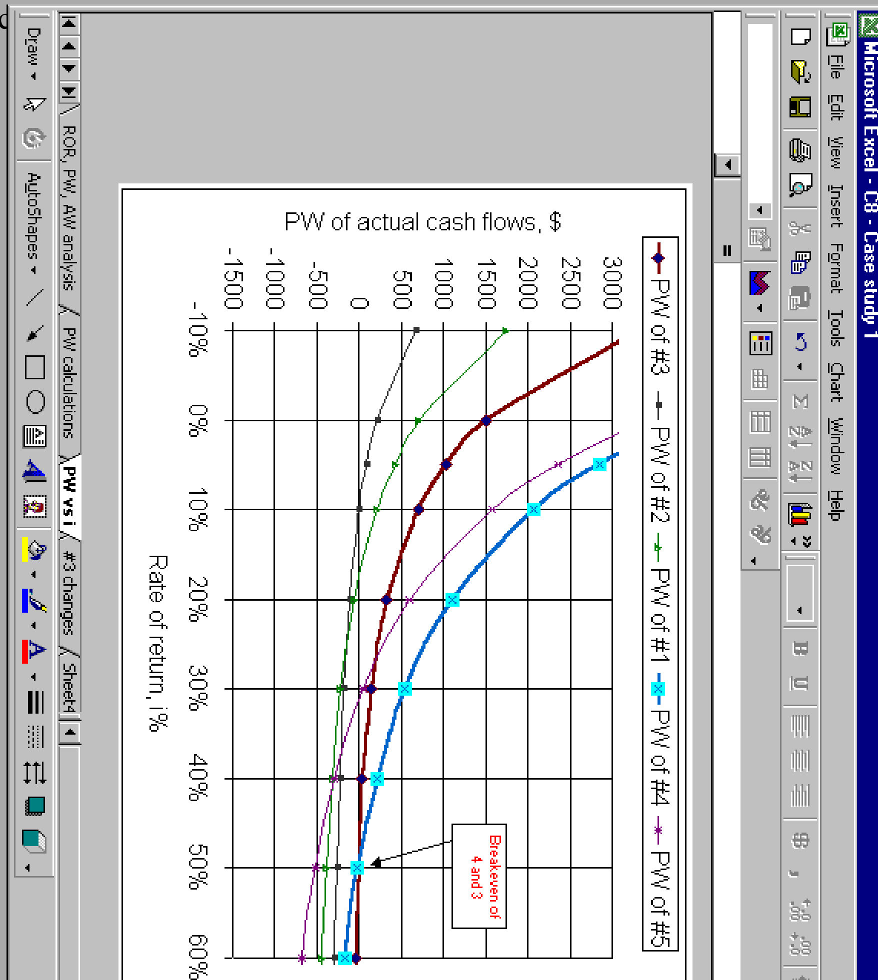
Microsoft Excel - C8 - Case study 1

	A	B	C	D	E	F	G	H	I
1	MARR =	25%	ROR, PW, AW analysis			(Cash flows in $1,000)			
2	Alternative		#3	#2	#1	#4		#5	
3	Initial cost		$ -	$ (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	Option i*		46.41%	10.07%	17.44%	49.08%		31.11%	
21	Retain or eliminate?		Retain	Eliminate	Eliminate	Retain		Retain	
22	Incremental i*						49.85%		#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			

3. Do incremental ROR analysis after removing #1 and #2. See row 22. 4-to-3 comparison 4-to-3 yields 59.85%, 5-to-4 has no return because all incremental cash flows are 0 or negative. PW at 25% is $785.25 for #4, which is the largest PW.

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

4. PW vs. i c



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 Solver on Excel with a target cell of G22 (to be 25% or .25 on the Solver window) and changing cell of C6. 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.

Case Study 2 Solution

1. By inspection only: Select Plan A since its cash flow total at 0% is $300, while Plan B produces a loss of the same amount ($-300).

2. Calculations for the following are shown on the spreadsheet below.

   PW at MARR approach:

   PW at 15%: PW_A = -$81.38 and PW_B = +$81.38. Plan B is selected
   PW at 50%: PW_A = +$16.05 and PW_B = -$16.05. Plan A is selected.

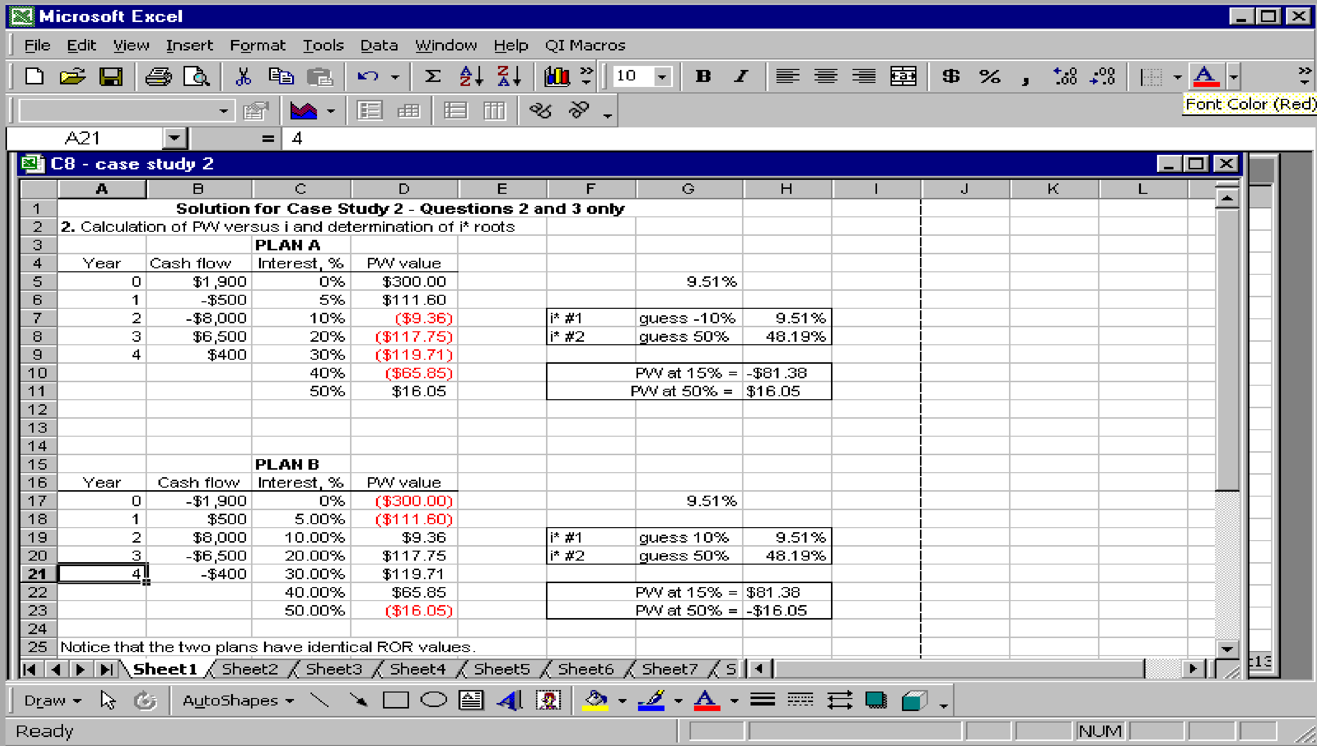
   The decisions contradict each other when the MARR is different. It does not seem logical to accept plan A at a higher interest rate (50%) and at 0%, but reject it at a mid-point interest rate (15%). The PW at MARR method is not working!

   ROR approach:

   The cash flow series have two sign changes, so a maximum of two roots may be found. An ROR analysis using Excel functions for the two plans produce two identical roots for each plan:

$$i^*_1 = 9.51\% \quad \text{and} \quad i^*_2 = 48.19\%$$

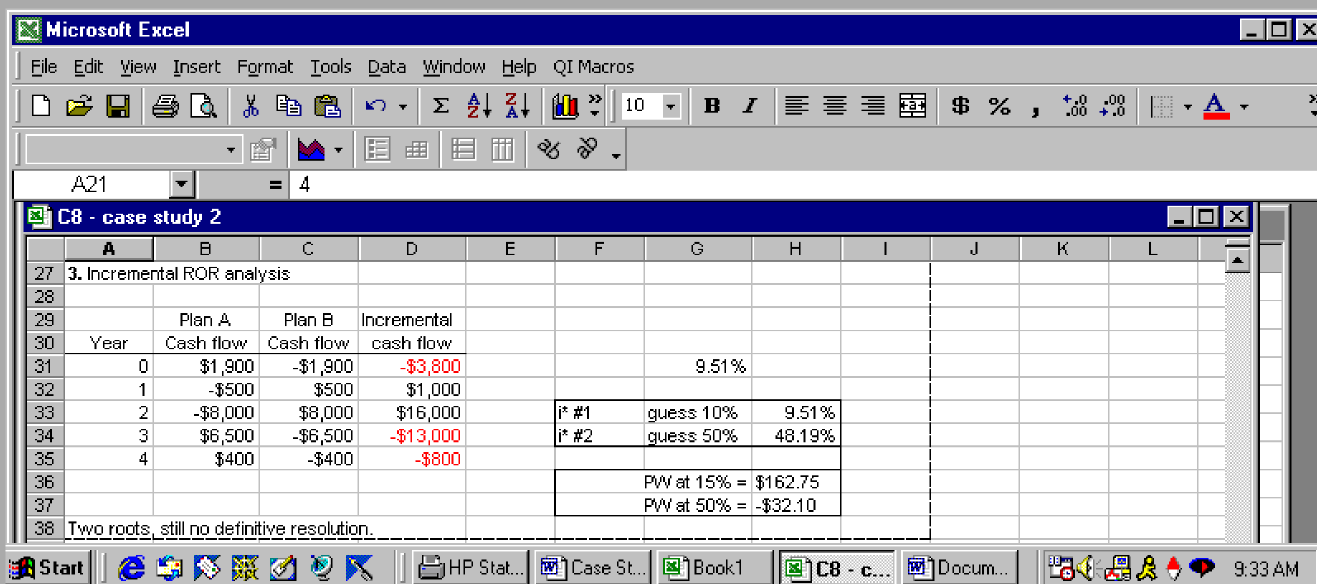
   There are two i* values; it is not clear which value to use for a decision on project acceptability. Further, when there are multiple i* values, the PW analysis 'at the MARR' does not work, as demonstrated above.



	A	B	C	D	E	F	G	H
1		Solution for Case Study 2 - Questions 2 and 3 only						
2	2. Calculation of PW versus i and determination of i* roots							
3			PLAN A					
4	Year	Cash flow	Interest, %	PW value				
5	0	$1,900	0%	$300.00			9.51%	
6	1	-$500	5%	$111.60				
7	2	-$8,000	10%	($9.36)		i* #1	guess -10%	9.51%
8	3	$6,500	20%	($117.75)		i* #2	guess 50%	48.19%
9	4	$400	30%	($119.71)				
10			40%	($65.85)			PW at 15% =	-$81.38
11			50%	$16.05			PW at 50% =	$16.05
12								
13								
14								
15			PLAN B					
16	Year	Cash flow	Interest, %	PW value				
17	0	-$1,900	0%	($300.00)			9.51%	
18	1	$500	5.00%	($111.60)				
19	2	$8,000	10.00%	$9.36		i* #1	guess 10%	9.51%
20	3	-$6,500	20.00%	$117.75		i* #2	guess 50%	48.19%
21	4	-$400	30.00%	$119.71				
22			40.00%	$65.85			PW at 15% =	$81.38
23			50.00%	($16.05)			PW at 50% =	-$16.05
24								
25	Notice that the two plans have identical ROR values.							

3. Incremental ROR analysis is shown on the spreadsheet below.

Plan B has a larger initial investment than A. The incremental cash flow series (B-A) has two sign changes. The use of the IRR function finds the same two roots: 9.51% and 48.19%. Incremental ROR analysis offers no definitive resolution.



	A	B	C	D	E	F	G	H
27	3. Incremental ROR analysis							
28								
29		Plan A	Plan B	Incremental				
30	Year	Cash flow	Cash flow	cash flow				
31	0	$1,900	-$1,900	-$3,800			9.51%	
32	1	-$500	$500	$1,000				
33	2	-$8,000	$8,000	$16,000		i* #1	guess 10%	9.51%
34	3	$6,500	-$6,500	-$13,000		i* #2	guess 50%	48.19%
35	4	$400	-$400	-$800				
36							PW at 15% =	$162.75
37							PW at 50% =	-$32.10
38	Two roots, still no definitive resolution.							

4. Composite rate of return approach

Plan A (a) MARR = 15% and c = 15%

F0 = 1900; F1 = 1900(1.15) -500 = 1685; F2 = 1685(1.15) -8000 = -6062.25;
F3 = -6062.25(1+ i') +6500 = 437.75 –6062.25i'
F4 = 0 = F3(1+ i') +400
So i' = 13.06% < MARR = 15%. Reject Plan A.

(b) MARR = 15% and c = 45%

F0 = 1900; F1=1900(1.45) -500 = 2255;
F2 = 2255(1.45) -8000 = -4730.25; F3 = -4730.25(1+ i') +6500 = 1769.75 – 4730.25i' F4 = 0 = F3(1+ i') +400.
So i' = 43.31% > MARR= 15%. Accept Plan A.

(c) MARR = 50% and c = 50%

F0 = 1900; F1 = 1900(1.50) -500 = 2350; F2 = 2350(1.50) -8000 = -4475;
F3 = -4475(1+i') +6500 = -4475i' + 2025
F4 = 0 = F3(1+ i') +400.
So i ' = 51.16% > MARR = 50%. Accept Plan A.

Plan B (a) MARR = 15% and c = 15%

F0 = -1900; F1 = -1900(1+ i') +500; F2 = $-1900(1+ i')^2$ +500(1+ i') +8000;
F3 = (1.15)F2 –6500
F4 = 0 = F3(1.15) -400.
So i' = 17.74% > MARR = 15%. Accept Plan B.

(b) MARR = 15% and c = 45%

F0 = -1900; F1 = -1900(1+i') +500; F2 = $-1900(1+ i')^2$ +500(1+ i') +8000;
F3 = $-1900(1.45)(1+ i')^2$ +500(1.45)(1+ i') +8000(1.45) –6500
F4 = 0 = F3(1.45) - 400.
So i' = 46.14% > MARR = 15%. Accept Plan B

(c) MARR = 50% and c = 50%

F0 = -1900; F1 = -1900(1+ i') +500; F2 = $-1900(1+ i')^2$ +500(1+ i') +8000;
F3 = $-1900(1.5)(1+ i')^2$ +500(1.5)(1+ i') +8000(1.5) – 6500
F4 = 0 = F3(1.5) - 400.
So i' = 49.30% < MARR = 50%. Reject Plan B.

d) Discussion: Plan B is superior to Plan A for c values below i^*_2, i.e., B's composite rate of return is higher. However, for c values above i^*_2, plan A gives a higher (composite) rate of return.

Conclusion: The composite rate of return evaluation yields unambiguous results when a reinvestment rate is specified.

Chapter 9

Benefit/Cost Analysis and Public Sector Economics

Solutions to Problems

9.1 (a) Public sector projects usually require large initial investments while many private sector investments may be medium to small.

(b) Public sector projects usually have long lives (30-50 years) while private sector projects are usually in the 2-25 year range.

(c) Public sector projects are usually funded from taxes, government bonds, or user fees. Private sector projects are usually funded by stocks, corporate bonds, or bank loans.

(d) Public sector projects use the term discount rate, not MARR. The discount rate is usually in the 4 – 10% range, thus it is lower than most private sector MARR values.

9.2 (a) Private (b) Private (c) Public (d) Public (e) Public
(f) Private

9.3 (a) Benefit (b) Cost (c) Cost (d) Disbenefit (e) Benefit (f) Disbenefit

9.4 Some different dimensions are:

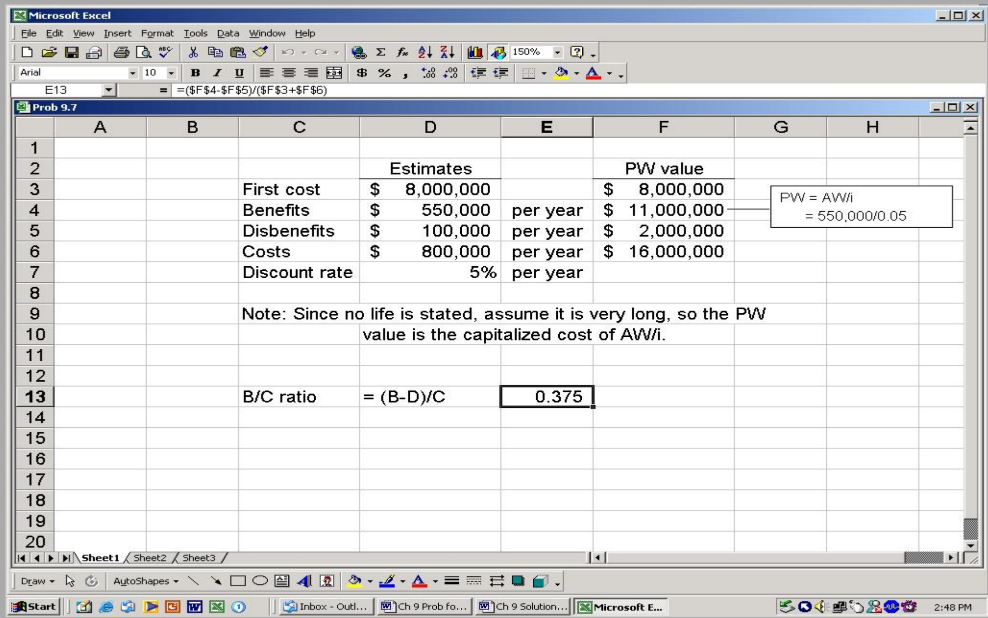
1. Contractor is involved in design of highway; contractor is not provided with the final plans before building the highway.
2. Obtaining project financing may be a partial responsibility in conjunction with the government unit.
3. Corporation will probably operate the highway (tolls, maintenance, management) for some years after construction.
4. Corporation will legally own the highway right of way and improvements until contracted time is over and title transfer occurs.
5. Profit (return on investment) will be stated in the contract.

9.5 (a) Amount of financing for construction is too low, and usage rate is too low to cover cost of operation and agreed-to profit.
(b) Special government-guaranteed loans and subsidies may be arranged at original contract time in case these types of financial problems arise later.

9.6 (a) $B/C = \dfrac{600{,}000 - 100{,}000}{450{,}000} = 1.11$

(b) $B\text{-}C = 600{,}000 - 100{,}000 - 450{,}000 = \$+50{,}000$

9.7 (a) Use Excel and assume an infinite life. Calculate the capitalized costs for all annual amount estimates.



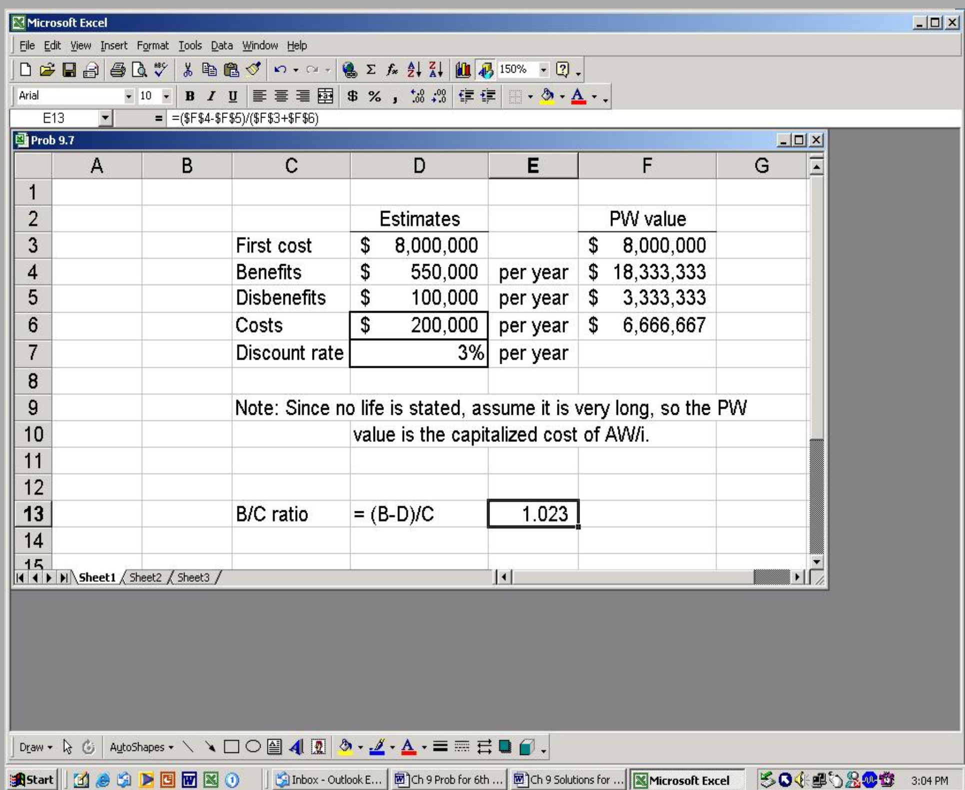
E13 =($F$4-$F$5)/($F$3+$F$6)

	C	D	E	F
		Estimates		PW value
	First cost	$ 8,000,000		$ 8,000,000
	Benefits	$ 550,000	per year	$ 11,000,000
	Disbenefits	$ 100,000	per year	$ 2,000,000
	Costs	$ 800,000	per year	$ 16,000,000
	Discount rate	5%	per year	
	B/C ratio	= (B-D)/C	0.375	

PW = AW/i
= 550,000/0.05

Note: Since no life is stated, assume it is very long, so the PW value is the capitalized cost of AW/i.

(b) Change cell D6 to $200,000 to get B/C = 1.023.



E13 =($F$4-$F$5)/($F$3+$F$6)

	C	D	E	F
		Estimates		PW value
	First cost	$ 8,000,000		$ 8,000,000
	Benefits	$ 550,000	per year	$ 18,333,333
	Disbenefits	$ 100,000	per year	$ 3,333,333
	Costs	$ 200,000	per year	$ 6,666,667
	Discount rate	3%	per year	
	B/C ratio	= (B-D)/C	1.023	

Note: Since no life is stated, assume it is very long, so the PW value is the capitalized cost of AW/i.

9.8 $1.0 = \dfrac{(12)(\text{value of a life})}{(200)(90{,}000{,}000)}$

Value of a life = \$1.5 billion

9.9 Annual cost = 30,000(0.025)

= \$750 per year/household

Let x = number of households

Total annual cost, C = (750)(x)

Let y = \$ health benefit per household for the 1% of households

Total annual benefits, B = (0.01x)(y)

$$1.0 = B/C = B/(750)(x)$$

$$B = (750)(x)$$

Substitute B = (0.01x)(y)

$$(0.01x)(y) = 750x$$

$$y = \$75{,}000 \text{ per year}$$

9.10 All parts are solved on the spreadsheet once it is formatted using cell references.

Prob 9.10

	A	B	C	D	E	F
1						
2						
3		B/C equation = annual benefit/annual cost				
4						For B/C = 1.0,
5	Prob	Median HH income	% of HH	AW of Cost	% affected	annual benefit is
6						
7	9.9	\$ 30,000	2.50%	750	1%	\$ 75,000
8						
9	9.10a	\$ 18,000	2.0%	360	1%	\$ 36,000
10						
11	9.10b	\$ 30,000	2.5%	750	0.5%	\$ 150,000
12						
13	9.10c	\$ 18,000	2.5%	450	2.50%	\$ 18,000
14		Answer: Change cell E13 until \$18,000 ishows in F13.				
15		Or, realize the percentage, p, must be 2.5% to obtain 450/p = 18,000.				

B=\$D7/\$E7

Note in part (b) how much larger ($150,000) than the median income ($30,000) the required benefit becomes as fewer households are affected

9.11 (a) Cost = 4,000,000(0.04) + 300,000
= $460,000 per year

$$B/C = \frac{550{,}000 - 90{,}000}{460{,}000} = 1.0$$

(b) Cost = 4,000,000(0.04)
= $160,000 per year

B - C = (550,000 – 90,000) – (160,000 + 300,000) = 0.0

The project is just economically acceptable using benefit/cost analysis.

9.12 Cost = 150,000(A/P,3%,20) + 12,000
= 150,000(0.06722) + 12,000
= $22,083 per year

Benefits = 24,000(2)(0.50)
= $24,000 per year

B/C = 24,00/22,083_ = 1.087

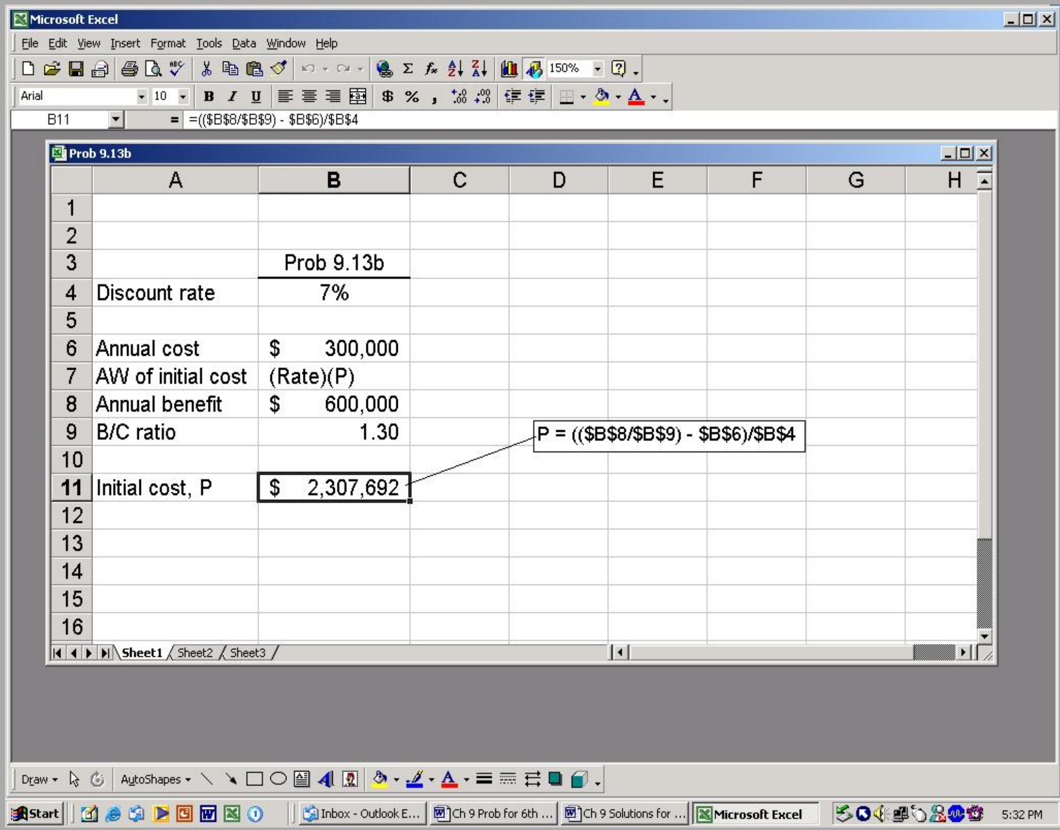
The project is marginally economically justified.

9.13 (a) By-hand solution: First, set up AW value relation of the initial cost, P capitalized a 7%. Then determine P for B/C = 1.3.

$$1.3 = \frac{600{,}000}{P(0.07) + 300{,}000}$$

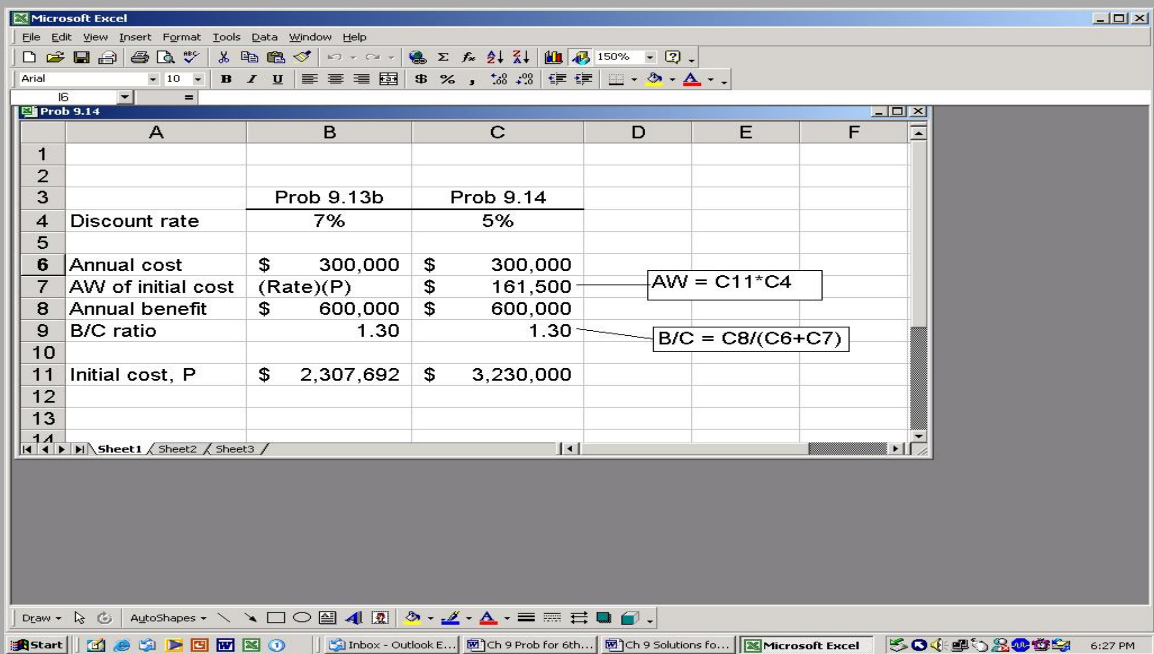
P = [(600,000/1.3) – 300,000]/0.07 = $2,307,692

(b) Spreadsheet solution: Set up the spreadsheet to calculate P = $2,307,692.



	A	B
1		
2		
3		Prob 9.13b
4	Discount rate	7%
5		
6	Annual cost	$ 300,000
7	AW of initial cost	(Rate)(P)
8	Annual benefit	$ 600,000
9	B/C ratio	1.30
10		
11	Initial cost, P	$ 2,307,692

9.14 Same spreadsheet, except change the discount rate and equations for AW and B/C. The B/C value is the same at 1.3, so the project is still justified.



	A	B	C
1			
2			
3		Prob 9.13b	Prob 9.14
4	Discount rate	7%	5%
5			
6	Annual cost	$ 300,000	$ 300,000
7	AW of initial cost	(Rate)(P)	$ 161,500
8	Annual benefit	$ 600,000	$ 600,000
9	B/C ratio	1.30	1.30
10			
11	Initial cost, P	$ 2,307,692	$ 3,230,000

9.15 $$1.7 = \frac{150{,}000 - \text{M\&O costs}}{1{,}000{,}000(A/P,6\%,30)}$$

$$1.7 = \frac{150{,}000 - \text{M\&O costs}}{1{,}000{,}000(0.07265)}$$

M&O costs = $26,495 per year

9.16 Convert all estimates to PW values.

$$\begin{aligned}\text{PW disbenefits} &= 45{,}000(P/A,6\%,15)\\ &= 45{,}000(9.7122)\\ &= \$437{,}049\end{aligned}$$

$$\begin{aligned}\text{PW M\&O Cost} &= 300{,}000(P/A,6\%,15)\\ &= 300{,}000(9.7122)\\ &= \$2{,}913{,}660\end{aligned}$$

$$B/C = \frac{3{,}800{,}000 - 437{,}049}{2{,}200{,}000 + 2{,}913{,}660}$$

$$\begin{aligned}&= 3{,}362{,}951/5{,}113{,}660\\ &= 0.66\end{aligned}$$

9.17 (a) AW of Cost = 30,000,000(0.08) + 100,000
= $2,500,000 per year

$$B/C = \frac{2{,}800{,}000}{2{,}500{,}000} = 1.12$$

Construct the dam.

(b) Calculate the CC of the initial cost to obtain AW for denominator.

B/C = 1.12

B/C = (2,800,000)/(100,000+30,000,000*(0.08))

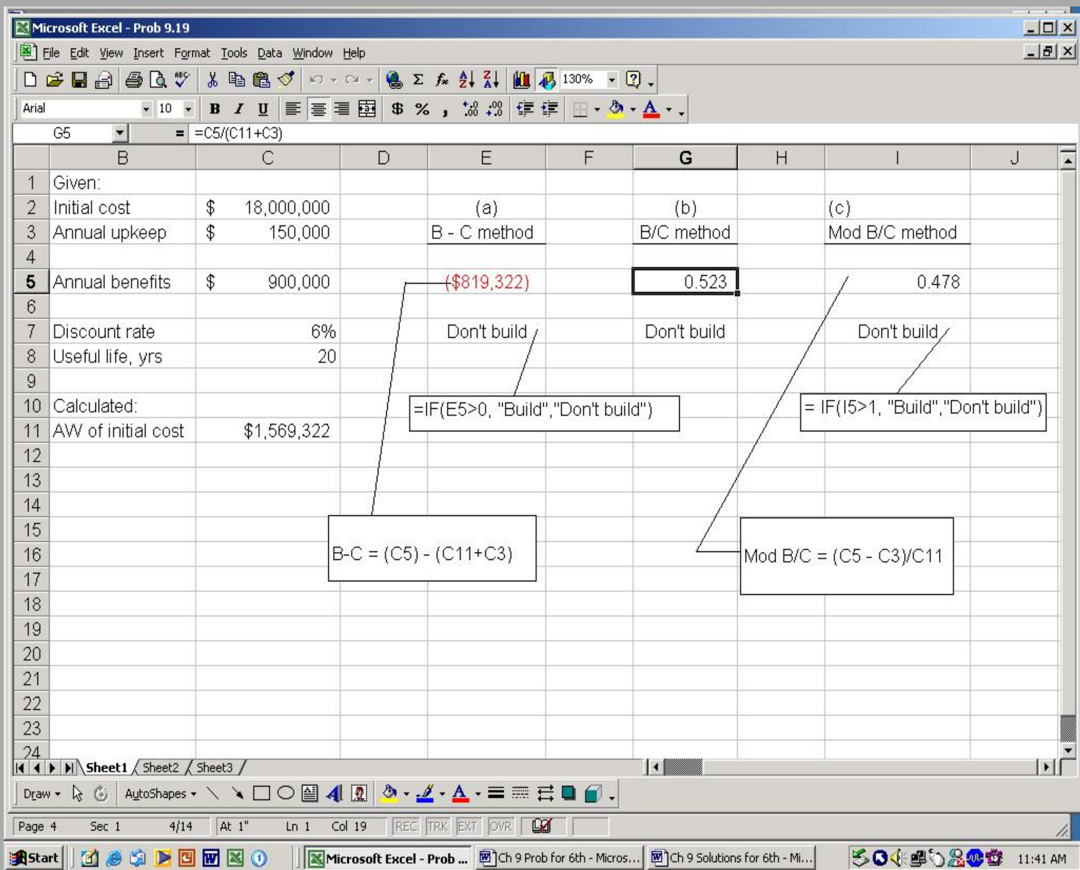
9.18 $AW = C = 2{,}200{,}000(0.12) + 10{,}000 + 65{,}000(A/F,12\%,15)$
$= 264{,}000 + 10{,}000 + 65{,}000(0.02682)$
$= \$275{,}743$

Annual Benefit = B = 90,000 – 10,000 = $80,000

B/C = 80,000/ 275,743 = 0.29

Since B/C < 1.0, the dam should not be constructed.

9.19 Calculate the AW of initial cost, then the 3 B/C measures of worth. The roadway should not be built.



9.20 (a) $AW = C = 1{,}500{,}000(A/P,6\%,20) + 25{,}000$
$= 1{,}500{,}000(0.08718) + 25{,}000$
$= \$155{,}770$

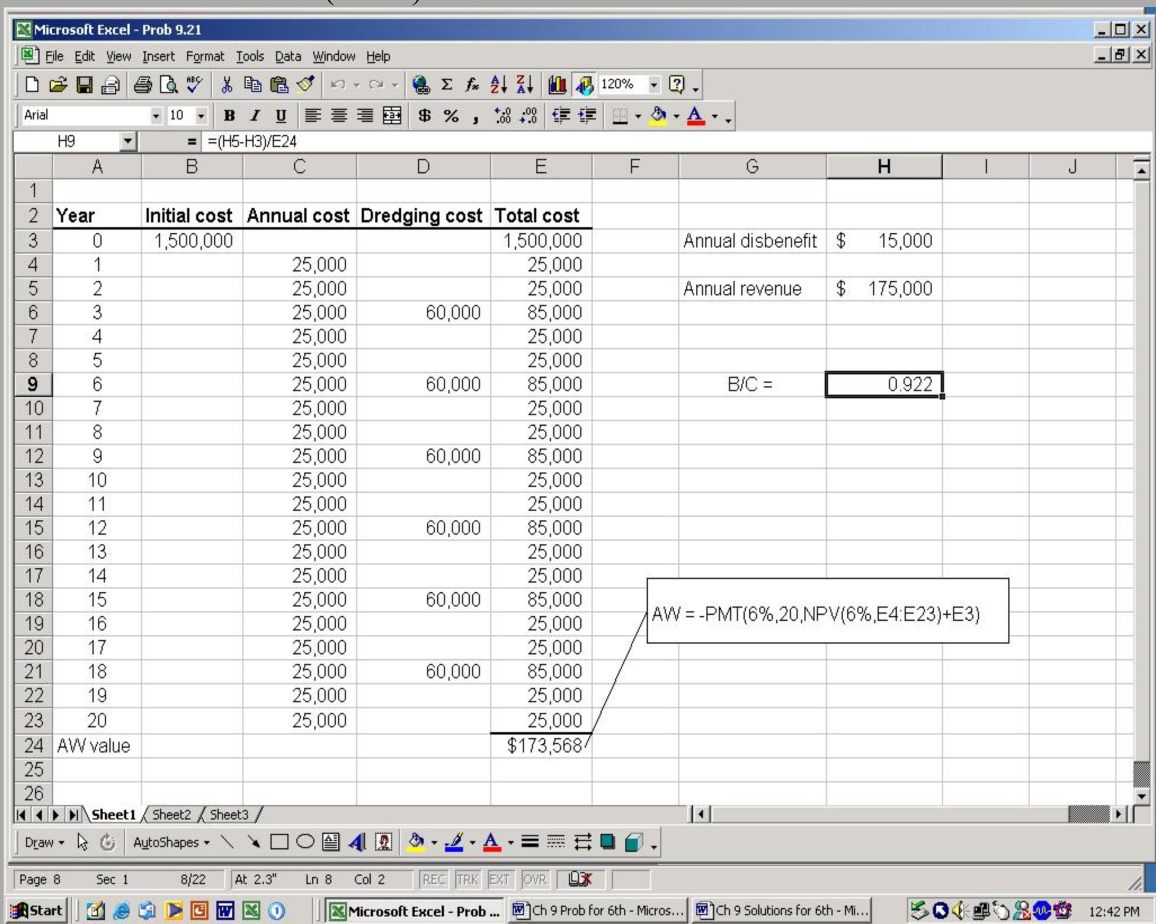
Annual revenue = B = \$175,000

B/C = 175,000/155,770 = 1.12
Since B/C > 1.0, the canals should be extended.

(b) For modified B/C ratio,
$C = 1{,}500{,}000(A/P,6\%,20) = \$130{,}770$
B = 175,000 – 25,000 = 150,000

Modified B/C = 150,000/130,770
= 1.15
Since modified B/C > 1.0, canals should be extended.

9.21 (a) Determine the AW of the initial cost, annual cost and recurring dredging cost, then calculate (B – D)/C.



Microsoft Excel - Prob 9.21

H9 = =(H5-H3)/E24

	A	B	C	D	E	F	G	H
1								
2	Year	Initial cost	Annual cost	Dredging cost	Total cost			
3	0	1,500,000			1,500,000		Annual disbenefit	$ 15,000
4	1		25,000		25,000			
5	2		25,000		25,000		Annual revenue	$ 175,000
6	3		25,000	60,000	85,000			
7	4		25,000		25,000			
8	5		25,000		25,000			
9	6		25,000	60,000	85,000		B/C =	0.922
10	7		25,000		25,000			
11	8		25,000		25,000			
12	9		25,000	60,000	85,000			
13	10		25,000		25,000			
14	11		25,000		25,000			
15	12		25,000	60,000	85,000			
16	13		25,000		25,000			
17	14		25,000		25,000			
18	15		25,000	60,000	85,000			
19	16		25,000		25,000			
20	17		25,000		25,000			
21	18		25,000	60,000	85,000			
22	19		25,000		25,000			
23	20		25,000		25,000			
24	AW value				$173,568			

AW = -PMT(6%,20,NPV(6%,E4:E23)+E3)

The disbenefit of $15,000 per year and the dredging cost each third year have reduced the B/C ratio to below 1.0; the canals should not be extended now.

(b) AW = C = 1,500,000(A/P,6%,20) + 25,000 + 60,000[(P/F,6%,3) + (P/F,6%,6)
+ (P/F,6%,9) + (P/F,6%,12) + (P/F,6%,15) + (P/F,6%,18)](A/P,6%,20)
= 1,500,000 (0.08718) + 25,000 + 60,000 [0.8396 + 0.7050 + 0.5919 +
0.4970 + 0.4173 + 0.3503](0.08718)
= $173,560

Annual disbenefit = D = $15,000
Annual revenue = B = $175,000

(B – D)/C = (175,000 – 15,000)/173,560 = 0.922

As above, the disbenefit of $15,000 per year and the dredging cost each third year have reduced the B/C ratio to below 1.0; the canals should not be extended now.

9.22 Alternative B has a larger total annual cost; it must be incrementally justified. Use PW values. Benefit is the difference in damage costs. For B incrementally over A:

Incr cost = (800,000 – 600,000) + (70,000 – 50,000)(P/A,8%,20)
= $200,000 + 20,000(9.8181)
= $396,362

Incr benefit = (950,000 – 250,000)(P/F,8%,6)
= 700,000(0.6302)
= 441,140

Incr B/C = 441,140/396,362
= 1.11

Select alternative B.

9.23 Annual cost of long route = 21,000,000(0.06) + 40,000 + 21,000,000(0.10)
(A/F,6%,10)
= 1,260,000 + 40,000 + 2,100,000(0.07587)
= $1,459,327
Annual cost of short route = 45,000,000(0.06) + 15,000 + 45,000,000(0.10)
(A/F,6%,10)
= 2,700,000 + 15,000 + 4,500,000(0.07587)

= $3,056,415

The short route must be incrementally justified.

Extra cost for short route = 3,056,415 – 1,459,327
= \$1,597,088

Incremental benefits of short route = 400,000(0.35)(25 – 10) + 900,000
= \$3,000,000

$$\text{Incr B/C}_{\text{short}} = \frac{3{,}000{,}000}{1{,}597{,}088} = 1.88$$

Build the short route.

9.24 Justify extra cost of downtown (DT) location.

Extra cost for DT site = 11,000,000(0.08)
= \$880,000

Extra benefits for DT site = 350,000 + 400,000
= \$750,000

Incremental B/C_{DT} = 750,000/880,000
= 0.85

The city should build on the west side site.

9.25 East coast site has the larger total cost (J17). Set up the spreadsheet to calculate AW values in \$1 million. First, perform B/C on west coast site since do-nothing is an option. It is justified. Then use incremental values to evaluate East versus West. It is also justified since Δ(B/C) = 2.05. Select east coast site.

Microsoft Excel — Prob 9.25

L13 = =M11/M9

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		West Coast Site					East Coast Site						
2		Initial		Annual	Total		Initial		Annual	Total			
3	Year	cost	Dredging	M&O	costs		cost	Dredging	M&O	costs			
4	0	21	5		26.0		8	12		20.0		(B-D)/C of West	
5	1			1.5	1.5		8		0.8	8.8		2.29	Justified
6	2			1.5	1.5				0.8	0.8			
7	3			1.5	1.5				0.8	0.8		East v. West	
8	4			1.5	1.5			1.2	0.8	2.0		Incremental (B-D)/C	
9	5			1.5	1.5				0.8	0.8		ΔC =	\$0.244
10	6		2	1.5	3.5				0.8	0.8			
11	7			1.5	1.5				0.8	0.8		ΔB =	\$ 0.500
12	8			1.5	1.5			1.32	0.8	2.12			
13	9			1.5	1.5				0.8	0.8		2.05	Justified
14	10			1.5	1.5				0.8	0.8			
15	11			1.5	1.5				0.8	0.8			
16	12		2.2	1.5	3.7				0.8	0.8			
17	13			1.5	1.5					\$3.96			
18	14			1.5	1.5								
19	15			1.5	1.5								
20	16			1.5	1.5								
21	17			1.5	1.5								
22	18		2.42	1.5	3.92								
23	19			1.5	1.5								
24	20			1.5	1.5								
25	AW value				\$3.72								
26	Benefits	5 mil @ 2.50 =		12.5			8 mil @ 2.00 =		16		Disc rate	4%	
27	Disbenefits			4					7				

=(I26-D26)-(I27-D27)

AW = -PMT(\$L\$26,12,NPV(\$L\$26,J5:J16)+J4)

AW = -(PMT(\$L\$26,20,NPV(\$L\$26,E5:E24)+E4))

9.26 First compare program 1 to do-nothing (DN).

$$\begin{aligned}\text{Cost/household/mo} &= \$60(A/P,0.5\%,60)\\ &= 60(0.01933)\\ &= \$1.16\end{aligned}$$

$$\begin{aligned}B/C_1 &= 1.25/1.16\\ &= 1.08 \qquad\qquad \text{Eliminate DN}\end{aligned}$$

Compare program 2 to program 1.

$$\begin{aligned}\Delta\text{cost} &= 500(A/P,0.5\%,60) - 60(A/P,0.5\%,60)\\ &= (500 - 60)(0.01933)\\ &= \$8.51\end{aligned}$$

$$\begin{aligned}\Delta\text{benefits} &= 8 - 1.25\\ &= \$6.75\end{aligned}$$

$$\begin{aligned}\text{Incr } B/C_2 &= 6.75/8.51\\ &= 0.79 \qquad\qquad \text{Eliminate program 2}\end{aligned}$$

The utility should undertake program 1.

9.27 Using the capital recovery costs, solar is the more costly alternative.

$$\begin{aligned}\Delta\text{cost} &= (4{,}500{,}000 - 2{,}000{,}000)(A/P,0.75\%,72)\\ &\quad - (150{,}000 - 0)(A/F,0.75\%,72)\\ &= 2{,}500{,}000(0.01803) - 150{,}000(0.01053)\\ &= \$43{,}496\end{aligned}$$

$$\begin{aligned}\Delta\text{benefits} &= 50{,}000 - 10{,}000\\ &= \$40{,}000\end{aligned}$$

$$\text{Incr } B/C = 40{,}000/43{,}496 = 0.92$$

Select the conventional system.

9.28 (a) Location E

$$\begin{aligned}AW = C &= 3{,}000{,}000(0.12) + 50{,}000\\ &= \$410{,}000\end{aligned}$$

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

Location W
AW = 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. Location W is now incrementally compared to E.

Δcost of W = 880,000 – 410,000
= \$470,000

9.28 (cont) Δbenefits of W = 700,000 – 500,000
= \$200,000

Incr disbenefits of W = 40,000 – 30,000
= \$10,000

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

Since incr(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.

Location W
ΔB = \$200,000
ΔD = \$10,000
ΔC = (7 million – 3 million)(0.12)
= \$480,000
ΔM&O = (65,000 – 25,000) – 50,000
= \$-10,000
Note that M&O is now an incremental cost 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.

9.29 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.

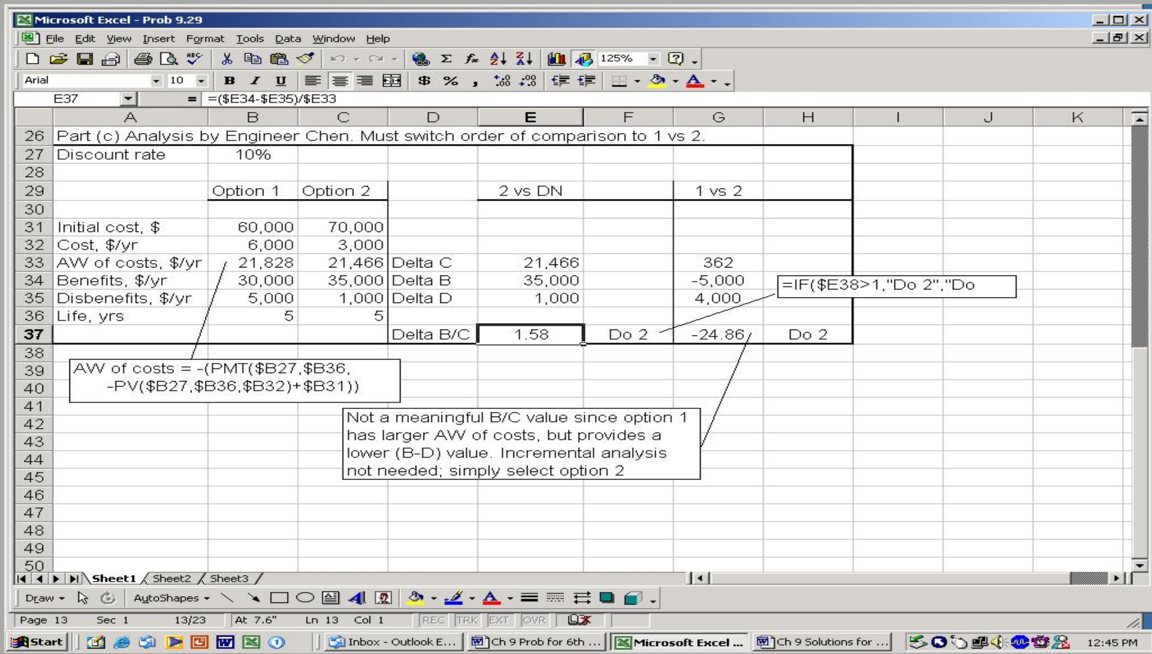
9.29 (cont)

Microsoft Excel - Prob 9.29

	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")



Microsoft Excel - Prob 9.29

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

9.30 Find the AW of costs for each technique, order them, and determine the Incr B/C values.

AW of costs = installed cost(A/P,15%,10) + AOC

9.30 (cont)

Technique	AW of cost calculation
1	15,000(A/P,15%,10) + 10,000 = 15,000(0.19925) + 10,000 = $12,989
2	19,000(A/P,15%,10) + 12,000 = 19,000(0.19925) + 12,000 = $15,786
3	25,000(A/P,15%,10) + 9,000 = 25,000(0.19925) + 9,000 = $13,981
4	33,000(A/P,15%,10) + 11,000 = 33,000(0.19925) + 11,000 = $17,575

Order of incremental analysis is: DN, 1, 3, 2, 4.

<u>Technique 1 vs DN (current)</u>

B/C = 15,000/12,989
= 1.15 > 1.0 Eliminate DN, keep technique 1.

<u>Technique 3 vs 1</u>

ΔC = 13,981 – 12,989 = $992

ΔB = 19,000 – 15,000 = $4,000

ΔB/C = 4,000/992
= 4.03 > 1 Eliminate technique 1, keep 3.

<u>Technique 2 vs 3</u>

ΔC = 15,786 - 13,981 = $1,805

ΔB = 20,000 – 19,000 = $1,000

ΔB/C = 1,000/1,805
= 0.55 < 1.0 Eliminate technique 2, keep 3.

<u>Technique 4 vs 3</u>

ΔC = 17,575 - 13,981 = $3,594

ΔB = 22,000 -19,000 = $3,000

ΔB/C = 3,000/3,594
= 0.83 < 1.0 Eliminate technique 4, keep 3

Replace the current method with technique 3.

9.31 Determine the AW of costs for each technique and calculate overall B/C. Select all four since all have B/C > 1.0.

AW of costs = E$5 - PMT(15%,10,E$4)

1	A	B	C	D	E
2	Technique	1	2	3	4
3					
4	Installed cost	15,000	19,000	25,000	33,000
5	AOC	10,000	12,000	9,000	11,000
6	AW of costs	$12,989	$ 15,786	$ 13,981	$ 17,575
7					
8	Benefits	15,000	20,000	19,000	22,000
9					
10	B/C	1.15	1.27	1.36	1.25
11					
12	Select?	Yes	Yes	Yes	Yes

9.32 Combine the investment and installation costs, difference in usage fees define benefits. Use the procedure in Section 9.3 to solve. Benefits are the incremental amounts for lowered costs of annual usage for each larger size pipe.

1, 2. Order of incremental analysis:

Size	130	150	200	230
Total first cost, $	9,780	11,310	14,580	17,350
3. Annual benefits, $	--	200	600	300

4. Not used since the benefits are defined by usage costs.

5-7. Determine incremental B and C and select at each pairwise comparison of defender vs challenger.

<u>150 vs 130 mm</u>

$\Delta C = (11{,}310 - 9{,}780)(A/P,8\%,15)$
$= 1{,}530(0.11683)$
$= \$178.75$

$\Delta B = 6{,}000 - 5{,}800$
$= \$200$

$\Delta B/C = 200/178.75$
$= 1.12 > 1.0$ Eliminate 130 mm size.

<u>200 vs 150 mm</u>

$\Delta C = (14{,}580 - 11{,}310)(A/P,8\%,15)$
$= 3270(0.11683)$
$= \$382.03$

$\Delta B = 5800 - 5200$
$= \$600$

$\Delta B/C = 600/382.03$
$= 1.57 > 1.0$ Eliminate 150 mm size.

<u>230 vs 200 mm</u>

$\Delta C = (17{,}350 - 14{,}580)(A/P,8\%,15)$
$= 2770(0.11683)$
$= \$323.62$

$\Delta B = 5200 - 4900$
$= \$300$

$\Delta B/C = 0.93 < 1.0$ Eliminate 230 mm size.

Select 200 mm size.

9.33 Compare A to DN since it is not necessary to select one of the sites.

A vs DN

AW of Cost = 50(A/P,10%,5) + 3
= 50(0.26380) + 3
= 16.19

AW of Benefits = 20 – 0.5
= 19.5

$$B/C = \frac{19.5}{16.19} = 1.20 > 1.0$$

Eliminate DN.

B vs A

$\Delta C = (90 - 50)(A/P,10\%,5) + (4 - 3)$
$= 40(0.26380) + 1$
$= \$11.552$

$\Delta B = (29 - 20) - (1.5 - 0.5) = 8$

$\Delta B/C = 8/11.552$
$= 0.69 < 1.0$ Eliminate B.

C vs A

$\Delta C = (200 - 50)(A/P,10\%,5) + (6 - 3)$
$= 150(0.26380) + 3$
$= 42.57$

$\Delta B = (61 - 20) - (2.1 - 0.5) = 39.4$

$\Delta B/C = 39.4/42.57$
$= 0.93 < 1.0$ Eliminate C

Select site A

9.34 (a) Calculate the B/C of each proposal for initial screening (row 6). Four locations are retained – F, D, E and G. No need to compare F vs DN since one site must be selected. Site D is the one selected.

	A	B	C	D	E	F	G	H
1	Loan rate, %/year	4%						
2	Location	F	B	D	E	A	G	C
3	First cost, $ million	6	8	9	12	14	18	22
4	Cap rec cost, $100,000	240,000	320,000	360,000	480,000	560,000	720,000	880,000
5	Benefits, $/year	390,000	310,000	800,000	750,000	400,000	930,000	850,000
6	Site B/C (initial screening)	1.63	0.97	2.22	1.56	0.71	1.29	0.97
7	Retain?	Retain	No	Retain	Retain	No	Retain	No
8								
9	Comparison			D vs F	E vs D		G vs D	
10	Inc. cap rec cost			120,000	120,000		360,000	
11	Inc benefits			410,000	lower		130,000	
12	Inc B/C value			3.42			0.36	
13	Increment justified?			Yes	No		No	
14	Site selected			D	D		D	

=H$3*1000000*$B$1

=IF(H$6>1,"Retain","No")

(b) For independent projects, use the B/C values in row 6 of the Excel solution above and select the largest three of the four with B/C > 1.0. Those selected for are: <u>D, F, and E</u>.

9.35 (a) An incremental B/C analysis is necessary between Y and Z, if these are mutually exclusive alternatives.

(b) Independent projects. Accept Y and Z, since B/C > 1.0.

9.36 **<u>J vs DN</u>**

B/C = 1.10 > 1.0 Eliminate DN.

<u>K vs J</u>

B/C = 0.40 < 1.0 Eliminate K.

L vs J
B/C = 1.42 > 1.0 Eliminate J.

M to L
B/C = 0.08 < 1.0 Eliminate M.

Select alternative L.

Note: K and M can be eliminated initially because they have B/C < 1.0.

9.37 (a) Projects are listed by increasing PW of cost values. First find benefits for each alternative and then find incremental B/C ratios:

Benefits for P
$1.1 = B_P/10$
$B_P = 11$

Benefits for Q
$2.4 = B_Q/40$
$B_Q = 96$

Benefits for R
$1.4 = B_R/50$
$B_R = 70$

Benefits for S
$1.5 = B_S/80$
$B_S = 120$

Incremental B/C for Q vs P
$$B/C = \frac{96 - 11}{40 - 10} = 2.83$$

Incremental B/C for R vs P
$$B/C = \frac{70 - 11}{50 - 10} = 1.48$$

Incremental B/C for S vs P
$$B/C = \frac{120 - 11}{80 - 10} = 1.56$$

Incremental B/C for R vs Q

$$B/C = \frac{70 - 96}{50 - 40} = -2.60$$

Disregard due to less B for more C.

Incremental B/C for S vs Q

$$B/C = \frac{120 - 96}{80 - 40} = 0.60$$

Incremental B/C for S vs R

$$B/C = \frac{120 - 70}{80 - 50} = 1.67$$

(b) Compare P to DN; eliminate DN.
Compare Q to P; eliminate P.
Compare R to Q; disregarded.
Compare S to Q; eliminate S.
Select Q.

FE Review Solutions

9.38 Answer is (d)

9.39 Answer is (b)

9.40 Answer is (a)

9.41 Answer is (c)

9.42 Project B/C values are given. Incremental analysis is necessary to select one alternative. Answer is (d)

9.43 Answer is (c)

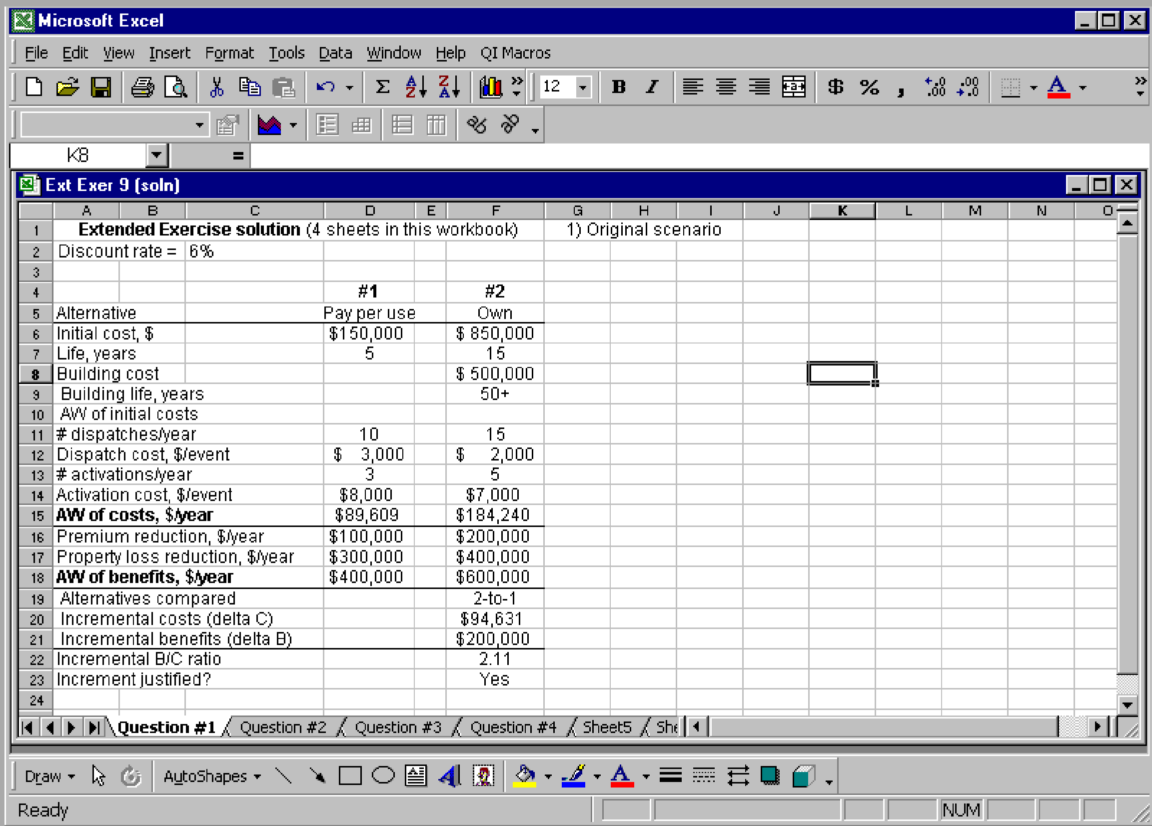
9.44 Answer is (a)

Extended Exercise solution

1. The spreadsheet shows the incremental B/C analysis. The truck should be purchased. The annual worth values for each alternative are determined using the equations:

$$AW_{pay\text{-}per\text{-}use} = 150{,}000(A/P,6\%,5) + 10(3000) + 3(8000) = \$89{,}609 \text{ (cell D15)}$$

$$AW_{own} = 850{,}000(A/P,6\%,15) + 500{,}000(A/P,6\%,50) + 15(2000) + 5(7000)$$
$$= \$184{,}240 \text{ (cell F15)}$$



	A–C	D	F	G
1	**Extended Exercise solution** (4 sheets in this workbook)			1) Original scenario
2	Discount rate = 6%			
3				
4		**#1**	**#2**	
5	Alternative	Pay per use	Own	
6	Initial cost, $	$150,000	$ 850,000	
7	Life, years	5	15	
8	Building cost		$ 500,000	
9	Building life, years		50+	
10	AW of initial costs			
11	# dispatches/year	10	15	
12	Dispatch cost, $/event	$ 3,000	$ 2,000	
13	# activations/year	3	5	
14	Activation cost, $/event	$8,000	$7,000	
15	**AW of costs, $/year**	$89,609	$184,240	
16	Premium reduction, $/year	$100,000	$200,000	
17	Property loss reduction, $/year	$300,000	$400,000	
18	**AW of benefits, $/year**	$400,000	$600,000	
19	Alternatives compared		2-to-1	
20	Incremental costs (delta C)		$94,631	
21	Incremental benefits (delta B)		$200,000	
22	Incremental B/C ratio		2.11	
23	Increment justified?		Yes	

2. The annual fee paid for 5 years now would have to be negative (cell D5) in that Brewster would have to pay Medford a ‘retainer fee’, so to speak, to possibly use the ladder truck. This is an economically unreasonable approach.

   Excel SOLVER is used to find the breakeven value of the initial cost when B/C = 1.0 (cell F21).

	A	B	C	D	E	F
1	Discount rate =		6%	2) Reduce annual fee (cell D5)		
2						
3				**#1**		**#2**
4	Alternative			Pay per use		Own
5	Initial cost, $			($301,107)		$ 850,000
6	Life, years			5		15
7	Building cost					$ 500,000
8	Building life, years					50+
9	AW of initial costs					
10	# dispatches/year			10		15
11	Dispatch cost, $/event			$ 3,000		$ 2,000
12	# activations/year			3		5
13	Activation cost, $/event			$8,000		$7,000
14	**AW of costs, $/year**			($17,482)		$182,518
15	Premium reduction, $/year			$100,000		$200,000
16	Property loss reduction, $/year			$300,000		$400,000
17	**AW of benefits, $/year**			$400,000		$600,000
18	Alternatives compared					2-to-1
19	Incremental costs (delta C)					$200,000
20	Incremental benefits (delta B)					$200,000
21	Incremental B/C ratio					1.00
22	Increment justified?					No

3. The building cost of over $2.2 million could be supported by the Brewster proposal (in cell F7), again found by using SOLVER. This is also not an economically reasonable alternative.

Discount rate =	6%	3) Increase building cost	
		#1	#2
Alternative		Pay per use	Own
Initial cost, $		$150,000	$ 850,000
Life, years		5	15
Building cost			$2,284,853
Building life, years			50+
AW of initial costs			
# dispatches/year		10	15
Dispatch cost, $/event		$ 3,000	$ 2,000
# activations/year		3	5
Activation cost, $/event		$8,000	$7,000
AW of costs, $/year		$89,609	$289,610
Premium reduction, $/year		$100,000	$200,000
Property loss reduction, $/year		$300,000	$400,000
AW of benefits, $/year		$400,000	$600,000
Alternatives compared			2-to-1
Incremental costs (delta C)			$200,000
Incremental benefits (delta B)			$200,000
Incremental B/C ratio			1.00
Increment justified?			No

4. The estimated sum of premium and property loss would need to be $523,714 or less (cell F17, SOLVER). This is not much of a reduction from the current estimate of $600,000.

Discount rate = 6%	4) Reduce: initial fee by 50%, event cost to level of 'own', increase ins. benefits	
	#1	**#2**
Alternative	Pay per use	Own
Initial cost, $	$75,000	$850,000
Life, years	5	15
Building cost		$500,000
Building life, years		50+
AW of initial costs		
# dispatches/year	10	15
Dispatch cost, $/event	$ 2,000	$ 2,000
# activations/year	3	5
Activation cost, $/event	$7,000	$7,000
AW of costs, $/year	$58,805	$182,518
Premium reduction, $/year	$100,000	$200,000
Property loss reduction, $/year	$300,000	$400,000
AW of benefits, $/year	$400,000	$523,714
Alternatives compared		2-to-1
Incremental costs (delta C)		$123,714
Incremental benefits (delta B)		$123,714
Incremental B/C ratio		1.00
Increment justified?		No

Case Study Solution

1. Installation cost = (3,500)[87.8/(0.067)(2)]
   = (3,500)(655)
   = $2,292,500

   Annual power cost = (655 poles)(2)(0.4)(12)(365)(0.08)
   = $183,610

   Total annual cost = 2,292,500(A/P,6%,5) + 183,610
   = $727,850

   If the accident reduction rate is assumed to be the same as that for closer spacing of lights,

   B/C = 1,111,500/727,850
   = 1.53

2. Night/day deaths, unlighted = 5/3 = 1.6

   Night/day deaths, lighted = 7/4 = 1.8

3. Installation cost = 2,500(87.8/0.067)
   = \$3,276,000

   Total annual cost = 3,276,000(A/P, 6%, 5) + 367,219
   = \$1,144,941

   B/C = 1,111,500/1,144,941
   = 0.97

4. Ratio of night/day accidents, lighted = $\dfrac{839}{2069}$ = 0.406

   If the same ratio is applied to unlighted sections, number of accidents prevented where property damage was involved would be calculated as follows:

   $0.406 = \dfrac{\text{no. of accidents}}{379}$

   no. accidents = 154

   no. prevented = 199 –154 = 45

5. For lights to be justified, benefits would have to be at least \$1,456,030 (instead of \$1,111,500). Therefore, the difference in the number of accidents would have to be:

   1,456,030 = (difference)(4500)
   Difference = 324

   No. of accidents would have to be = 1086 – 324 = 762

   Night/day ratio = $\dfrac{762}{2069}$ = 0.368

Chapter 10

Making Choices: the Method, MARR, and Multiple Attributes

Solutions to Problems

10.1 The circumstances are when the lives for all alternatives are: (1) finite and equal, or (2) considered infinite. It is also correct when (3) the evaluation will take place over a specified study period.

10.2 Incremental cash flow analysis is mandatory for the ROR method and B/C method. (It is noteworthy that if unequal-life cash flows are evaluated by ROR using an AW-based relation that reflects the differences in cash flows between two alternatives, the breakeven i* will be the same as the incremental i*. (See Table 10.2 and Section 10.1 for comments.)

10.3 Numerically largest means the alternative with the largest PW, AW or FW identifies the selected alternative. For both revenue and service alternatives, the largest number is chosen. For example, $-5000 is selected over $-10,000, and $+100 is selected over $-50.

10.4 (a) Hand solution: After consulting Table 10.1, choose the AW or PW method at 8% for equal lives of 8 years.

Computer solution: either the PMT function or the PV function can give single-cell solutions for each alternative.

In either case, select the alternative with the numerically largest value of AW or PW.

(b) (1) Hand solution: Find the PW for each cash flow series.

$$\begin{aligned} PW_8 &= -10{,}000 + 2000(P/F,18\%,8) + (6500 - 4000)\ (P/A,18\%,8) \\ &= -10{,}000 + 2000(0.2660) + 2500(4.0776) \\ &= \$726 \end{aligned}$$

$$\begin{aligned} PW_{10} &= -14{,}000 + 2500(P/F,18\%,8) + (10{,}000 - 5500)\ (P/A,18\%,8) \\ &= \$5014 \end{aligned}$$

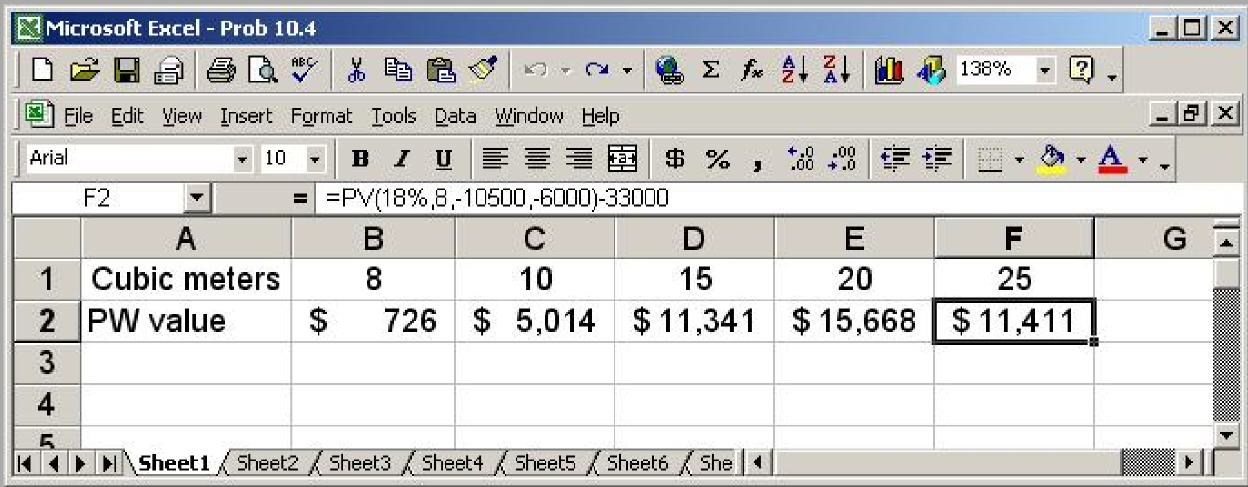
$$\begin{aligned} PW_{15} &= -18{,}000 + 3000(P/F,18\%,8) + (14{,}000 - 7000)\ (P/A,18\%,8) \\ &= \$11{,}341 \end{aligned}$$

$$PW_{20} = -24{,}000 + 3500(P/F,18\%,8) + (20{,}500 - 11{,}000)\ (P/A,18\%,8)$$
$$= \$15{,}668$$

$$PW_{25} = -33{,}000 + 6000(P/F,18\%,8) + (26{,}500 - 16{,}000)\ (P/A,18\%,8)$$
$$= \$11{,}411$$

Select the 20 cubic meter size.

Computer solution: Use the PV function to find the PW in a separate spreadsheet cell for each alternative. Select the 20 cubic meter alternative.



	A	B	C	D	E	F
1	Cubic meters	8	10	15	20	25
2	PW value	$ 726	$ 5,014	$ 11,341	$ 15,668	$ 11,411

(b) (2) Buy another 20 cubic meter truck, not a smaller size, because it is always correct to spend the largest amount that is economically justified.

10.5 (a) Hand solution: Choose the AW or PW method at 0.5% for equal lives over 60 months.

Computer solution: Either the PMT function or the PV function can give single-cell solutions for each alternative.

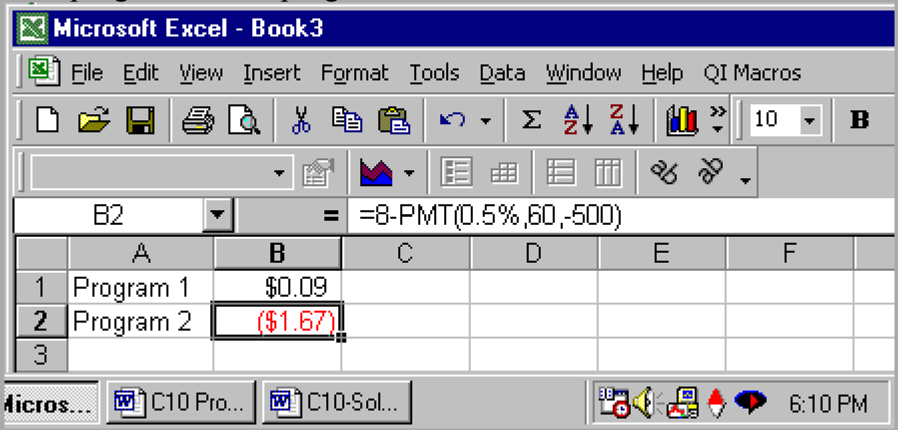
(b) The B/C method was the evaluation method in chapter 9, so rework it using AW. Hand solution: Find the AW for each cash flow series on a per household per month basis.

$$AW_1 = 1.25 – 60(A/P,0.5\%,60)$$
$$= 1.25 – 60(0.01933)$$
$$= 1.25 - 1.16$$
$$= \$0.09$$

$$AW_2 = 8.00 - 500(A/P,0.5\%,60)$$
$$= 8.00 – 9.67$$
$$= \$-1.67$$

Select program 1.

Computer solution: Develop the AW value using the PMT function in a separate cell for each program. Select program 1.



10.6 Long to infinite life alternatives. Examples are usually public sector projects such as dams, highways, buildings, railroads, etc.

10.7 (a) The expected return is 12 - 8 = 4% per year.
(b) Retain MARR = 12% and then estimate the project i*. Take the risk-related return expectation into account before deciding on the project. If 12% < i* < 17%, John must decide if the risk is worth less than 5% over MARR = 12%.

10.8 (a) Bonds are debt financing
(b) Stocks are always equity
(c) Equity
(d) Equity loans are debt financing, like house mortgage loan

10.9 The project that is rejected, say B, and has the next highest ROR measure, $i^*_{B,}$ in effect sets the MARR, because it's rate of return is a lost opportunity rate of return. Were any second alternative selected, project B would be it and the effective MARR would be i^*_B.

10.10 Before-tax opportunity cost is the 16.6% forgone rate. Determine the after-tax percentage after the effective tax rate (T_e) is calculated.

$$T_e = 0.06 + (0.94)(0.20) = 0.248$$

$$\text{After-tax MARR} = \text{Before-tax MARR}\,(1 - T_e) = 16.6\,(1 - 0.248)$$

$$= 12.48\%$$

10.11 (a) Select 2. It is the alternative investing the maximum available with incremental $i^* > 9\%$.
(b) Select 3.
(c) Select 3.
(d) MARR = 10% for alternative 4 is opportunity cost at $400,000 level, since 4 is the first unfunded project due to unavailability of funds.

10.12 Set the MARR at the cost of capital. Determine the rate of return for the cash flow estimates and select the best alternative. Examine the difference between the return and MARR to separately determine if it is large enough to cover the other factors for this selected alternative. (This is different than increasing the MARR before the evaluation to accommodate the factors.)

10.13 (a) MARR may tend to be set lower, based on the success of the last purchase.
(b) Set the MARR and then treat the risk associated with the purchase separately from the MARR.

10.14 (a) Calculate the two WACC values.

$$WACC_1 = 0.6(12\%) + 0.4\,(9\%) = 10.8\%$$
$$WACC_2 = 0.2(12\%) + 0.8(12.5\%) = 12.4\%$$

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.

Alternative 1: $10\% = WACC_1 = 0.6(12\%) + 0.4(x_1)$

$$x_1 = [10\% - 0.6(12\%)]/0.4$$
$$= 7\%$$

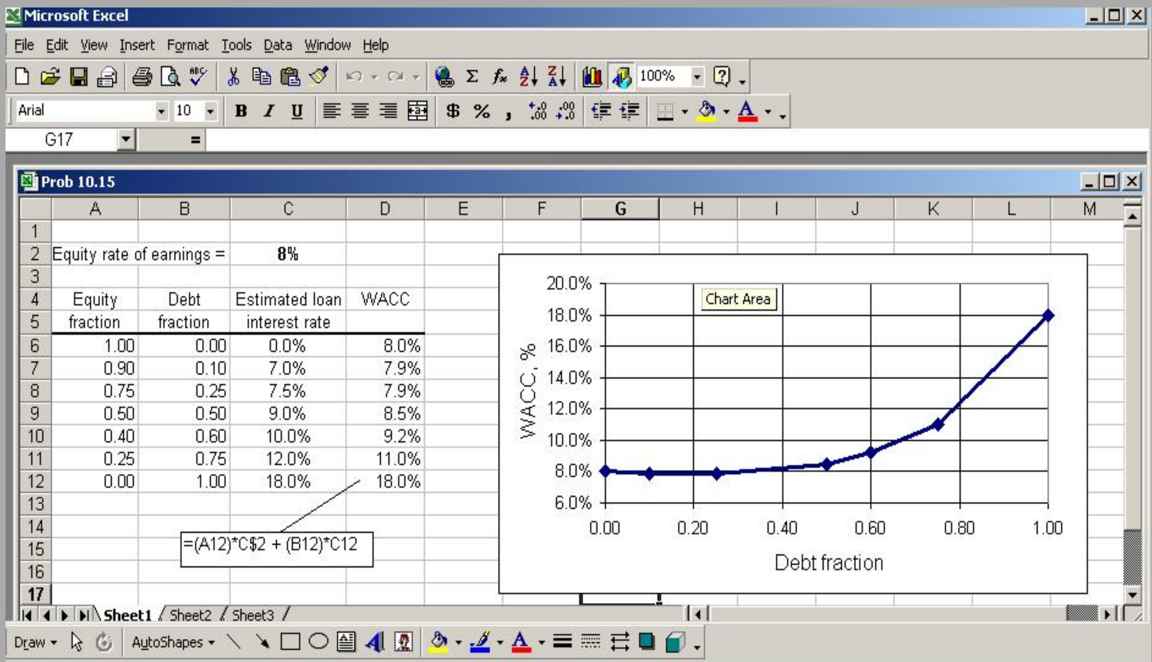
Debt capital cost would have to decrease from 9% to 7%.

Alternative 2: $10\% = WACC_2 = 0.2(12\%) + 0.8(x_2)$

$$x_2 = [10\% - 0.2(12\%)]/0.8$$
$$= 9.5\%$$

Debt capital cost would, again, have to decrease; now from 12.5% to 9.5%

10.15 The lowest WACC value of 7.9% occurs at the D-E mixes of $10,000 and $25,000 loan. This translates into funding between $75,000 and $90,000 from their own funds.



Equity rate of earnings = 8%

Equity fraction	Debt fraction	Estimated loan interest rate	WACC
1.00	0.00	0.0%	8.0%
0.90	0.10	7.0%	7.9%
0.75	0.25	7.5%	7.9%
0.50	0.50	9.0%	8.5%
0.40	0.60	10.0%	9.2%
0.25	0.75	12.0%	11.0%
0.00	1.00	18.0%	18.0%

=(A12)*C$2 + (B12)*C12

10.16 WACC = cost of debt capital + cost of equity capital

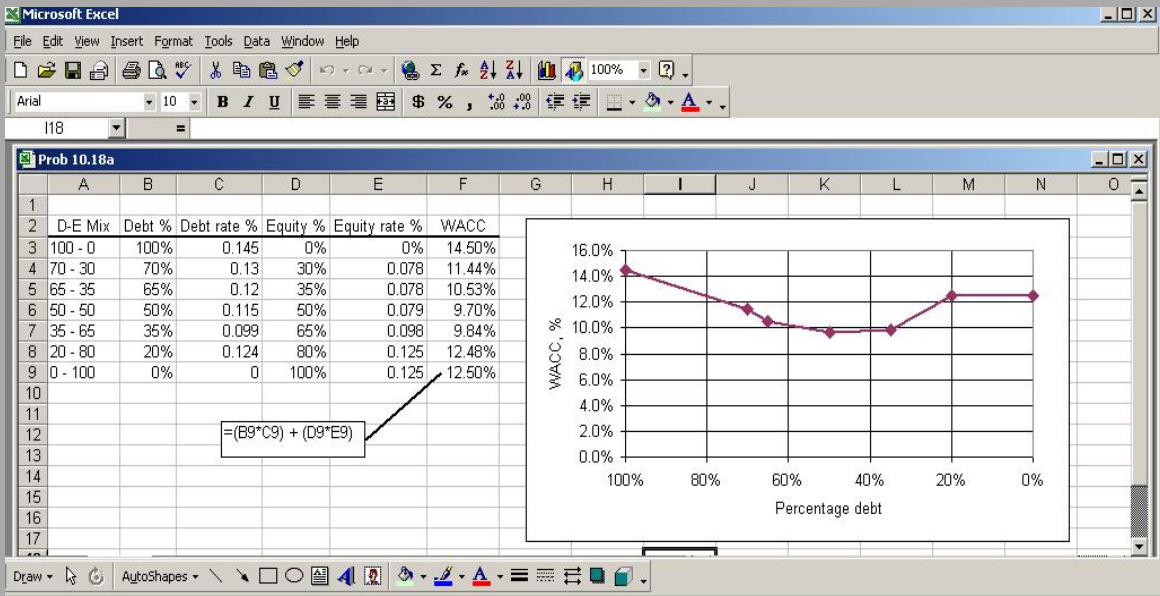
$$= (0.4)[0.667(8\%) + 0.333(10\%)] + (0.6)[(0.4)(5\%) + (0.6)(9\%)]$$
$$= 0.4[8.667\%] + 0.6\ [7.4\%]$$
$$= 7.907\%$$

10.17 (a) Compute and plot WACC for each D-E mix.

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.

10.18 (a) The spreadsheet shows a 50% - 50% mix to have the lowest WACC at 9.70%.



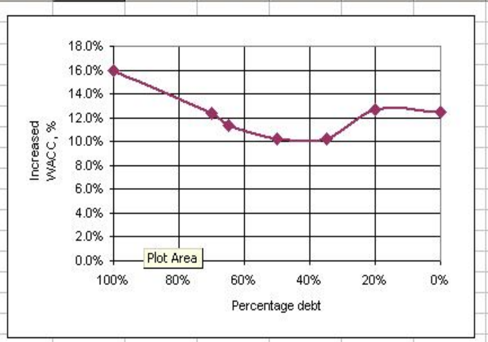
(b) Change the debt rate column (C to D) to add the 10% and observe the new plot.
Now debt of 35% (D-E of 35-65) has the lowest WACC = 10.18%.

Microsoft Excel — Prob 10.18b

	A	B	C	D	E	F	G
1				10% Increased			Increased
2	D-E Mix	Debt %	Debt rate %	Debt Rate %	Equity %	Equity rate %	WACC
3	100 - 0	100%	0.145	0.1595	0%	0%	15.95%
4	70 - 30	70%	0.13	0.143	30%	0.078	12.35%
5	65 - 35	65%	0.12	0.132	35%	0.078	11.31%
6	50 - 50	50%	0.115	0.1265	50%	0.079	10.28%
7	35 - 65	35%	0.099	0.1089	65%	0.098	10.18%
8	20 - 80	20%	0.124	0.1364	80%	0.125	12.73%
9	0 - 100	0%	0	0	100%	0.125	12.50%

=C8*1.1

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



10.19 Solve for the cost of debt capital, x.

$$
\begin{aligned}
\text{WACC} &= 10.7\% = 0.8(6\%) + (1-0.8)(x) \\
x &= (10.7 - 4.8)/0.2 \\
&= 29.5\%
\end{aligned}
$$

The rate of 29.5% for debt capital (loans, bonds, etc.) seems very high.

10.20 Before-taxes:

$$\text{WACC} = 0.4(9\%) + 0.6(12\%) = 10.8\% \text{ per year}$$

After-tax: Insert Equation [10.3] into the before-tax WACC relation.

$$
\begin{aligned}
\text{After-tax WACC} &= (\text{equity})(\text{equity rate}) + (\text{debt})(\text{before-tax debt rate})(1-T_e) \\
&= 0.4(9\%) + 0.6(12\%)(1-0.35) \\
&= 8.28\% \text{ per year}
\end{aligned}
$$

The tax advantage reduces the WACC from 10.8% to 8.28% per year, or 2.52% per year.

10.21 (a) Face value = $\frac{\$2,500,000}{0.97}$ = \$2,577,320

(b) Bond interest = $\frac{0.042(2,577,320)}{4}$ = \$27,062 every 3 months

Dividend quarterly net cash flow = \$27,062(1 - 0.35) = \$17,590

The rate of return equation per 3-months over 20(4) quarters is:

0 = 2,500,000 – 17,590(P/A,i*,80) – 2,577,320(P/F,i*,80)

i* = 0.732% per 3 months (RATE function)

Nominal i* = 2.928% per year

Effective i* = $(1.00732)^4 - 1$ = 2.96% per year

10.22 (a) Annual loan payment is the cost of the \$160,000 debt capital. First, determine the after-tax cost of debt capital.

10.22 (cont)

Debt cost of capital: before-tax $(1\text{-}T_e)$ = 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 principle 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 principle 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.

	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	

(c) After-tax WACC = 0.2(6.5%) + 0.8(9%(1-0.22)
= 6.916%

10.23 Equity cost of capital is stated as 6%. Debt cost of capital benefits from tax savings.

Before-tax bond annual interest = 4 million (0.08) = $320,000
Annual bond interest NCF = 320,000(1 – 0.4) = $192,000
Effective quarterly dividend = 192,000/4 = $48,000

Find quarterly i* using a PW relation.

$$0 = 4{,}000{,}000 - 48{,}000(P/A,i^*,40) - 4{,}000{,}000(P/F,i^*,40)$$

i* = 1.2% per quarter
= 4.8% per year (nominal)

Debt financing at 4.8% per year is cheaper than equity funds at 6% per year.

(Note: The correct answer is also obtained if the before-tax debt cost of 8% is used to estimate the after-tax debt cost of 8%(1 - 0.4) = 4.8% from Equation [10.3].)

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%

Bond issue:

Annual bond interest = 800,000(0.06) = $48,000
Tax saving = 48,000(0.40) = $19,200
Effective bond interest = 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* = 3.6% (RATE or IRR function)

Bond financing is cheaper.

(b) Bonds cost 6% per year, which is less than the 8% loan. The answer is the same before-taxes.

10.25 Face value of bond issue = (10,000,000)/ 0.975 = \$10,256,410

Annual bond interest = 0.0975(10,256,410) = \$1,000,000

Interest net cash flow = \$1,000,000(1 - 0.32) = \$680,000

The PW-based rate of return equation is:

$$0 = 10{,}000{,}000 – 680{,}000(P/A,i^*,30) – 10{,}256{,}410(P/F,i^*,30)$$

$i^* =$ 6.83% per year (Excel RATE function)

Bonds are cheaper than the bank loan at 7.5% with no tax advantage.

10.26 Dividend method:

$$R_e = DV_1/P + g$$
$$= 0.93/18.80 + 0.015$$
$$= 6.44\%$$

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.

10.27 Debt capital cost: 9.5% for \$6 million (60% of total capital)

Equity -- common stock: 100,000(32) = \$3.2 million or 32% of total capital

$$R_e = 1.10/ 32 + 0.02$$
$$= 5.44\%$$

Equity -- retained earnings: cost is 5.44% for this 8% of total capital.

$$\begin{aligned} WACC &= 0.6(9.5\%) + 0.32(5.44\%) + 0.08(5.44\%) \\ &= 7.88\% \end{aligned}$$

10.28 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. The safe return rate stayed about the same in the switch from US to Euro bonds.

10.29 Determine the effective annual interest rate i_a for each plan using the effective interest rate equation in chapter 4. All the dollar values can be neglected.

Plan 1:

i_a for debt $= (1 + 0.00583)^{12} -1 = 7.225\%$

i_a for equity $= (1 + 0.03)^2 - 1 = 6.09\%$

$WACC_A = 0.5(7.225\%) + 0.5(6.09\%) = 6.66\%$

Plan 2:

i_a for 100% equity $= WACC_B = (1 + 0.03)^2 - 1 = 6.09\%$

Plan 3:

i_a for 100% debt $= WACC_C = (1 + 0.00583)^{12} -1 = 7.225\%$

Plan 2: 100% equity has the lowest before-tax WACC.

10.30 (a) Equity capital: 50% of capital at 15% per year.

Debt capital: 15% in bonds and 35% in loans.

Cost of loans: 10.5% per year

Cost of bonds: 6% from the problem statement, or determine i*.

Bond annual interest per bond = $10,000(0.06) = $600

0 = 10,000 - 600(P/A,i*,15) - 10,000(P/F,i*,15)

i* = 6.0% (RATE function)

Before-tax WACC = 0.5(15%) + 0.15(6%) + 0.35(10.5%)
= 12.075%

(b) Use T_e = 35% to calculate after-tax WACC with Equation [10.3] inserted into Equation [10.1], as mentioned at the end of Section 10.3 in the text.

After-tax WACC = (equity)(equity rate) + (debt)(before-tax debt rate)(1–T_e)
= 0.5(15%) + [0.15(6%) + 0.35(10.5)](1-0.35)
= 10.47%

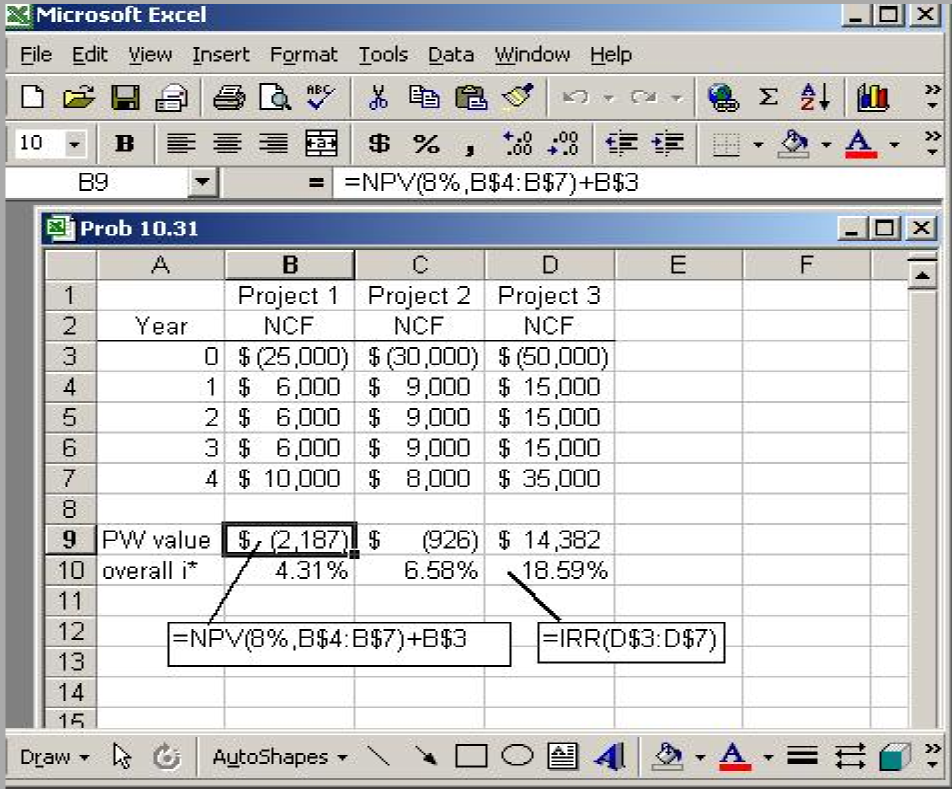
10.31 For the D-E mix of 70%-30%, WACC = 0.7(7.0%) + 0.3(10.34%) = 8.0%

MARR = WACC = 8%

(a) Independent projects: These are revenue projects. Fastest solution is to find PW at 8% for each project. Select all those with PW > 0.

PW_1 = -25,000 + 6,000 (P/A,8%,4) + 4,000 (P/F,8%,4)
PW_2 = -30,000 + 9,000 (P/A,8%,4) - 1,000 (P/F,8%,4)
PW_3 = -50,000 + 15,000 (P/A,8%,4) + 20,000 (P/F,8%,4)

Spreadsheet solution below shows PW at 8% and overall i*



B9 = =NPV(8%,B$4:B$7)+B$3

Prob 10.31

	A	B	C	D
1		Project 1	Project 2	Project 3
2	Year	NCF	NCF	NCF
3	0	$ (25,000)	$ (30,000)	$ (50,000)
4	1	$ 6,000	$ 9,000	$ 15,000
5	2	$ 6,000	$ 9,000	$ 15,000
6	3	$ 6,000	$ 9,000	$ 15,000
7	4	$ 10,000	$ 8,000	$ 35,000
8				
9	PW value	$ (2,187)	$ (926)	$ 14,382
10	overall i*	4.31%	6.58%	18.59%

=NPV(8%,B$4:B$7)+B$3

=IRR(D$3:D$7)

Independent: Only project 3 has PW > 0. Select it.

(b) Mutually exclusive: Since only $PW_3 > 0$, select it.

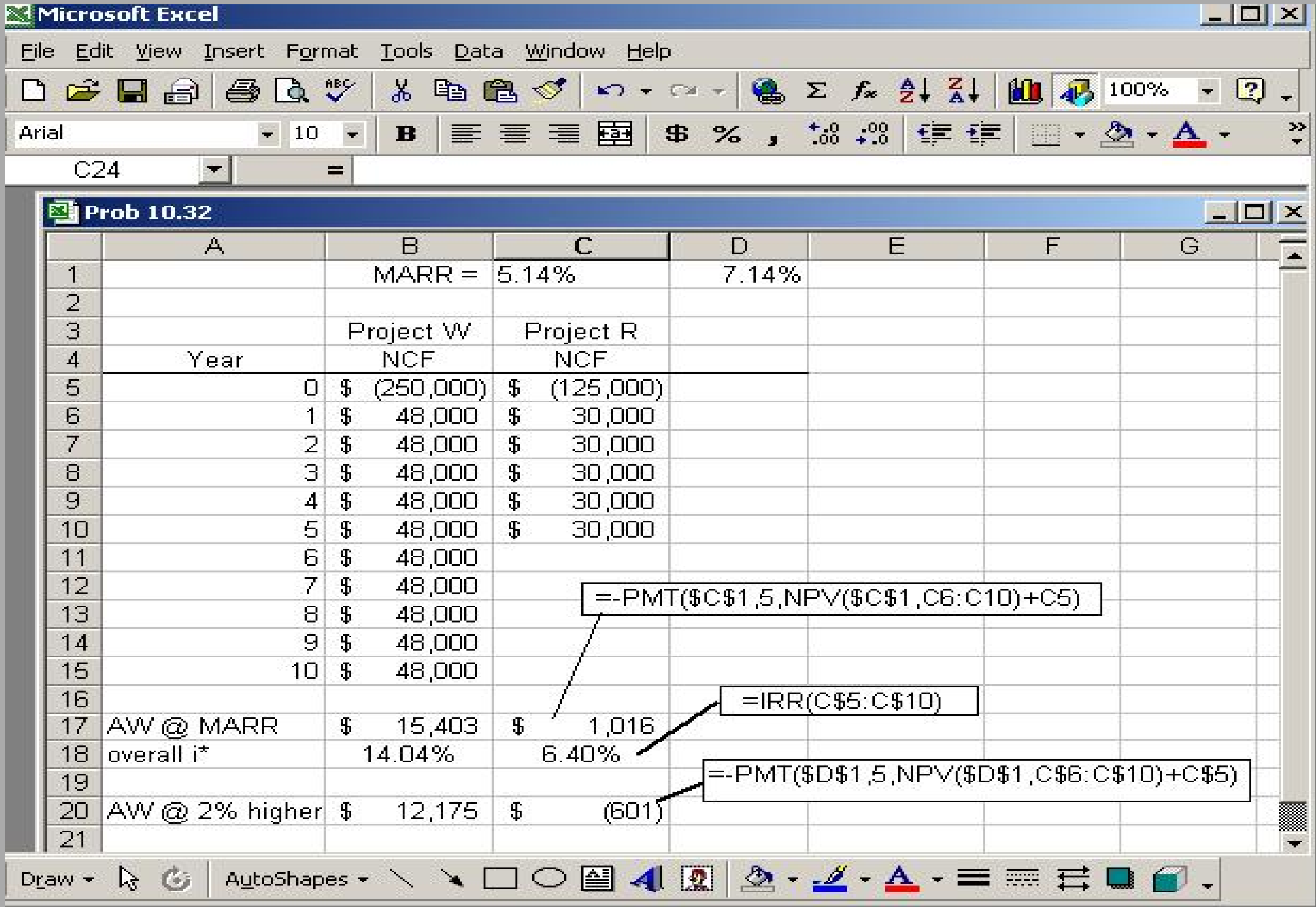
10.32 Two independent, revenue projects with different lives. Fastest solution is to find AW at MARR for each project. Select all those with AW > 0. Find WACC first.

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* = $[(1 + 0.05/4)^4 - 1] (1- 0.3)$
$= 5.095(0.7) = 3.5665\%$ per year

WACC = 0.4(7.5%) + 0.6(3.5665%) = 5.14% per year

MARR = WACC = 5.14%


Microsoft Excel

Prob 10.32

	A	B	C	D
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)	
21				

=-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 cells)

(b) With 2% added for higher risk, only project W is acceptable (row 20 cells)

10.33 One approach is to utilize a 'cost only' analysis and incrementally compare alternatives against each other without the possibility of selecting the do-nothing alternative.

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) will be hard to obtain and very expensive in terms of the interest rate charged.

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

MARR = 8.5% is known. Determine PW at the MARR.

$$\begin{aligned} PW &= -250{,}000 + 30{,}000(P/A,8.5\%,15) \\ &= -250{,}000 + 30{,}000(8.3042) \\ &= -250{,}000 + 249{,}126 \\ &= \$-874 \end{aligned}$$

Since PW < 0, 100% equity does not meet the MARR requirement.

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

$$\begin{aligned} \text{Loan principal} &= 250{,}000(0.60) = \$150{,}000 \\ \text{Loan payment} &= 150{,}000(A/P,9\%,15) \\ &= 150{,}000(0.12406) \\ &= \$18{,}609 \text{ per year} \end{aligned}$$

Cost of 60% debt capital is 9% for the loan.

WACC = 0.4(8.5%) + 0.6(9%) = 8.8%
MARR = 8.8%

$$\begin{aligned} \text{Annual NCF} &= \text{project NCF - loan payment} \\ &= \$30{,}000 - 18{,}609 = \$11{,}391 \end{aligned}$$

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

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

$$\begin{aligned} PW &= -100{,}000 + 11{,}391(P/A,8.8\%,15) \\ &= -100{,}000 + 11{,}391(8.1567) \\ &= \$ -7{,}087 \end{aligned}$$

Conclusion: PW < 0; a 60% debt-40% equity mix does not meet the MARR requirement.

10.36 Determine i* for each plan.

Plan 1: 80% equity means $480,000 funds are invested. Use a PW-based relation.

$0 = -480{,}000 + 90{,}000\,(P/A,i^*,7)$
$i_1^* = 7.30\%$ (RATE function)

Plan 2: 50% equity means $300,000 invested.

$0 = -300{,}000 + 90000\,(P/A,i^*,7)$
$i_2^* = 22.93\%$ (RATE function)

Plan 3: 10% equity means $240,000 invested.
$0 = -240{,}000 + 90{,}000(P/A,i^*,7)$
$i_3^* = 32.18\%$ (RATE function)

Determine the MARR values. (a) MARR = 7.5% all plans

(b) $MARR_1 = WACC_1 = 0.8(7.5\%) + 0.2(10\%) = 8.0\%$
$MARR_2 = WACC_2 = 0.5(7.5\%) + 0.5(10\%) = 8.75\%$
$MARR_3 = WACC_3 = 0.4(7.5\%) + 0.6(10\%) = 9.0\%$

(c) $MARR_1 = (8.00 + 7.5)/2 = 7.75\%$
$MARR_2 = (8.75 + 7.5)/2 = 8.125\%$
$MARR_3 = (9.00 + 7.5)/2 = 8.25\%$

Make the decisions using i* values for each plan.

		Part (a)		Part (b)		Part (c)	
Plan	i*	MARR	?[+]	MARR	?[+]	MARR	?[+]
1	7.3%	7.5%	N	8.00 %	N	7.75%	N
2	22.93	7.5	Y	8.75	Y	8.125	Y
3	32.18	7.5	Y	9.00	Y	8.25	Y

([+]Table legend: "?" poses the question "Is the plan justified in that i* > MARR?")

Same decision for all 3 options; plans 2 and 3 are acceptable.

10.37 (a) Find cost of equity capital using CAPM.

$$R_e = 4\% + 1.05(5\%) = 9.25\%$$
$$MARR = 9.25\%$$

Find i* on 50% equity investment.

$$0 = -5{,}000{,}000 + 2{,}000{,}000(P/A,i^*,6)$$
$$i^* = 32.66\% \qquad \text{(RATE function)}$$

The investment is economically acceptable since i* > MARR.

(b) Determine WACC and set MARR = WACC. For 50% debt financing at 8%,

$$WACC = MARR = 0.5(8\%) + 0.5(9.25\%) = 8.625\%$$

The investment is acceptable, since 32.66% > 8.625%.

10.38 All points will increase, except the 0% debt value. The new WACC curve is relatively higher at both the 0% debt and 100% debt points and the minimum WACC point will move to the right.

Conclusion: The minimum WACC will increase with a higher D-E mix, since debt and equity cost curves rise relative to those for lower D-E mixes.

10.39 If the debt-equity ratio 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.

10.40 Ratings by attribute with 10 for #1.

Attribute	Importance	Logic
1	10	Most important (10)
2	2.5	0.5(5) = 2.5
3	5	1/2(10) = 5
4	5	2(2.5) = 5
5	5	2(2.5) = 5

	27.5	

W_i = Score/27.5

Attribute	W_i
1	0.364
2	0.090
3	0.182
4	0.182
5	0.182
	1.000

10.41 Ratings by attribute with 10 for #1 and #5.

Attribute	Importance	Logic
1	100	Most important (100)
2	10	10% of problem
3	50	1/2(100)
4	37.5	0.75(50)
5	100	Same as #1

	297.5	

W_i = Score/297.5

Attribute	W_i
1	0.336
2	0.034
3	0.168
4	0.126
5	0.336
	1.000

10.42 Lease cost (as an alternative to purchase)
Insurance cost
Resale value
Safety features
Pick-up (acceleration)
Steering response
Quality of ride
Aerodynamic design
Options package
Cargo volume
Warranty
What friends own

10.43 Calculate W_i = importance score/sum and use Eq. [10.11] 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.

10.44 (a) Both sets of ratings give the same conclusion, alternative 1, but the consistency between raters should be improved somewhat. This result simply shows that the weighted evaluation method is relatively insensitive to attribute weights when an alternative (1 here) is favored by high (or disfavored by low) weights.

(b) Vice president

Take W_j from problem 10.43. Calculate R_j using Eq. [10.11].

Attribute	W_i	V_{ij} 1	2	3
1	0.10	3	4	10
2	0.40	28	40	28
3	0.50	50	40	45
		81	84	83

Conclusion: Select alternative 2.

Assistant vice president

Attribute	W_i	V_{ij} for alternatives 1	2	3
1	0.50	15	20	50
2	0.40	28	40	28
3	0.10	10	8	9
		53	68	87

Conclusion: Select 3.

(c) There is now a big difference for the asst. VP's alternative 3 and the VP has a very small difference between alternatives. The VP could very easily select alternative 3, since the R_j values are so close.

Reverse rating of VP and assistant VP makes only a small difference in choice, but it shows real difference in perspective. Rating differences on alternatives by attribute can make a significant difference in the alternative selected, based on these results.

10.45 Calculate W_i = importance score/sum and use Eq. [10.11] for R_j with the new factor (environmental cleanliness) included.

John as VP

		Alternative ratings		
Attribute	Importance Score	1	2	3
1. Economic return > MARR	100	50	70	100
2. High throughput	80	100	60	30
3. Low scrap rate	20	100	40	50
4. Environmental cleanliness	80	80	50	20

Attribute, i	Importance score	W_i	V_{ij} values 1	2	3
1	100	0.357	17.9	25.0	35.7
2	80	0.286	28.6	17.2	8.6
3	20	0.071	7.1	2.8	3.6
4	80	0.286	22.9	14.3	5.7
	280	1.000	76.5	59.3	53.6 = R_j

With R_1 = 76.5, select alternative 1

Note: This is the same selection as those of Problem 10.43 for the former VP or Asst. VP.

10.46 Sum the ratings in Table 10.5 over all six attributes.

	V_{ij} 1	2	3
Total	470	515	345

Select alternative 2; the same choice is made.

10.47 (a) Select A since PW is larger.

(b) Use Eq. [10.11] and manager scores for attributes.

$$W_i = \frac{\text{Importance score}}{\text{Sum}}$$

10.47 (cont)

Attribute, i	Importance (By mgr.)	W_i	R_j A	R_j B
1	100	0.57	0.57	0.51
2	35	0.20	0.07	0.20
3	20	0.11	0.11	0.10
4	20	0.11	0.03	0.11
	175		0.78	0.92

Select B.

(c) Use Eq. [10.11] and trainer scores for attributes.

Attribute i	Importance (By trainer)	W_i	R_j A	R_j B
1	80	0.40	0.40	0.36
2	10	0.05	0.02	0.05
3	100	0.50	0.50	0.45
4	10	0.05	0.01	0.05
	200		0.93	0.91

Select A, by a very small margin.

Note: 2 methods indicate A and 1 indicates B.

Extended Exercise Solution

1. Use scores as recorded to determine weights by Equation [10.10]. Note that the scores are not rank ordered, so a 1 indicates the most important attribute. Therefore the *lowest weight is the most important attribute*. The sum or average can be used to find the weights.

Attribute	Committee member 1	2	3	4	5	Sum	Avg.	W_j
A. Closeness to the citizenry	4	5	3	4	5	21	4.2	0.280
B. Annual cost	3	4	1	2	4	14	2.8	0.186
C. Response time	2	2	5	1	1	11	2.2	0.147
D. Coverage area	1	1	2	3	2	9	1.8	0.120
E. Safety of officers	5	3	4	5	3	20	4.0	0.267
Totals						75	15.0	1.000

W_j = sum/75 = average/15

For example, $W_1 = 21/75 = 0.280$ or $W_1 = 4.2/15 = 0.280$

$W_2 = 14/75 = .186$ or $W_2 = 2.8/15 = 0.186$

2. Attributes B, C, and D are retained. (The 'people factor' attributes have been removed.) Renumber the remaining attributes in the same order with scores of 1, 2, and 3.

Attribute	Committee member 1	2	3	4	5	Sum	Avg.	W_j
B. Annual cost	3	3	1	2	3	12	2.4	0.4
C. Response time	2	2	3	1	1	9	1.8	0.3
D. Coverage area	1	1	2	3	2	9	1.8	0.3
Totals						30	6.0	1.0

Now, W_j = sum/30 = average/6

3. Because the most important attribute lowest score of 1, select the *two smallest R_j values* in question 1. Therefore, the chief should choose the horse and foot options for the pilot study.

Case Study Solution

1. Set MARR = WACC

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

Equity Use Eq. [10.6]

$$R_e = \frac{0.50}{15} + 0.05 = 8.33\%$$

Debt Interest is tax deductible; use Eqs. [10.4] and [10.5].

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)(.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(8.3) = 6.85%

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

2. A: <u>50–50 D–E financing</u>

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*

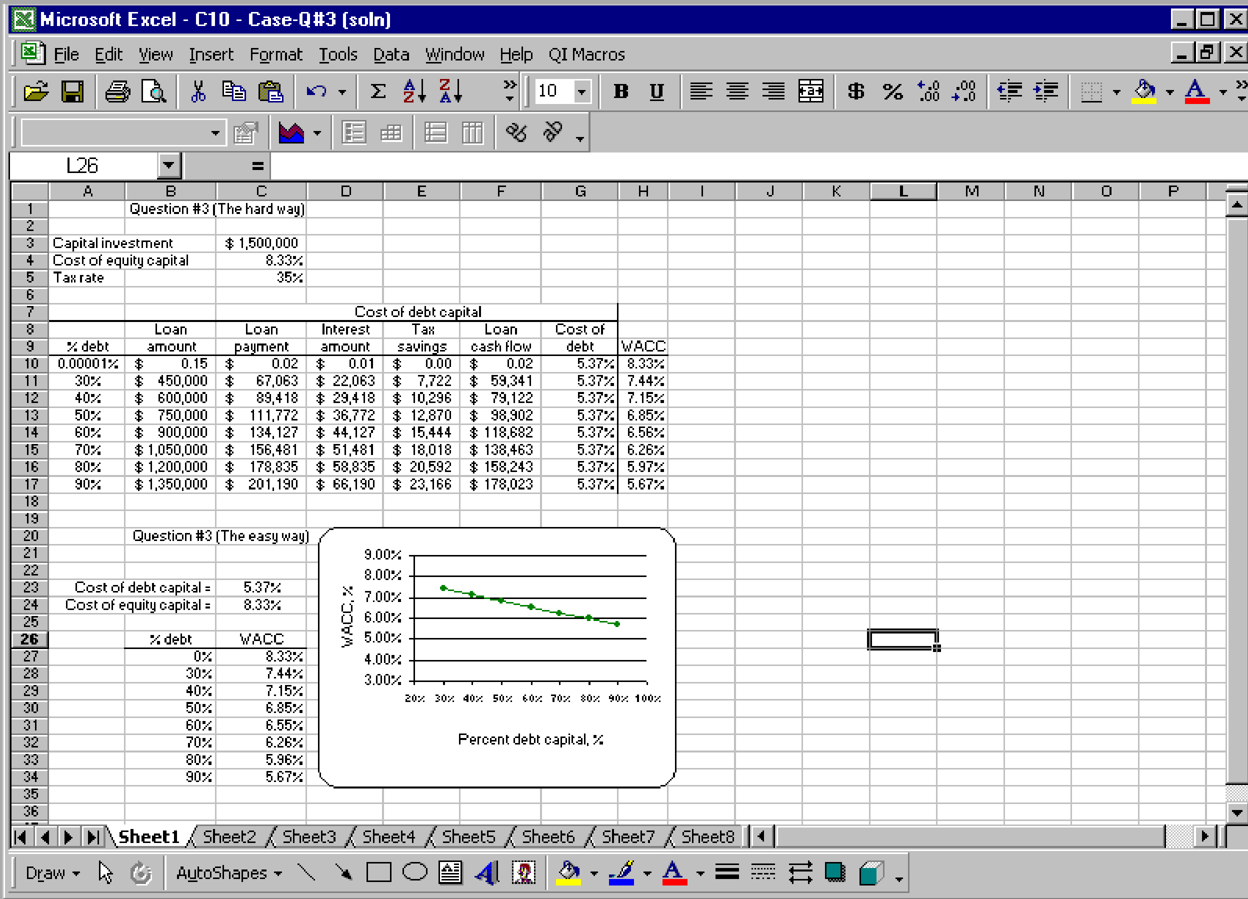
$0 = -1{,}500{,}000(A/P,i_B^*,10) + 200{,}000(A/F,i_B^*,10) + 195{,}000$

$i_B^* = 6.61\%$ (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, then obtains WACC) and the easy way (uses costs of capital from #1) to plot WACC.



Microsoft Excel - C10 - Case-Q#3 (soln)

Question #3 (The hard way)

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

	Cost of debt capital						
% debt	Loan amount	Loan payment	Interest amount	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%

Chapter 11

Replacement and Retention Decisions

Solutions to Problems

11.1 Specific assumptions about the challenger are:
1. Challenger is best alternative to defender now and it will be the best for all succeeding life cycles.
2. Cost of challenger will be same in all future life cycles.

11.2 The defender's value of P is its fair market value. If the asset must be updated or augmented, this cost is added to the first cost. Obtain market value estimates from expert appraisers, resellers or others familiar with the asset being evaluated.

11.3 The consultant's (external or outsider's) viewpoint is important to provide an unbiased analysis for both the defender and challenger, without owning or using either one.

11.4 (a) Defender first cost = blue book value = 10,000 – 3,000 = $7000

(b) Since the trade-in is inflated by $3000 over market value (blue book value)

Challenger first cost = sales price – (trade-in value – market value)
= P – (TIV – MV)
= 28,000 – (10,000 – 7000)
= $25,000

11.5 P = market value = $350,000
AOC = $125,000 per year
n = 2 years
S = $5,000

11.6 (a) Now, k = 2, n = 3 years more. Let MV_k = market value k years after purchase

$$P = MV_2 = 400{,}000 - 50{,}000(2)^{1.4} = \$268{,}050$$
$$S = MV_5 = 400{,}000 - 50{,}000(5)^{1.4} = \$\text{-}75{,}913$$
$$AOC = 10{,}000 + 100(k)^3 \text{ for } k = \text{year 3, 4, and 5}$$

k	3	4	5
Study period year, t	1	2	3
AOC	$12,700	16,400	22,500

(b) In 2 years, k = 4, n = 1 since it had an expected life of 5 years. more.

$$P = MV_4 = 400{,}000 - 50{,}000(4)^{1.4} = \$51{,}780$$
$$S = MV_5 = 400{,}000 - 50{,}000(5)^{1.4} = \$\text{-}75{,}913$$
$$AOC = 10{,}000 + 100(5)^3 = \$22{,}500 \quad \text{for year 5 only}$$

11.7 $P = MV = 85{,}000 - 10{,}000(1) = \$75{,}000$

$AOC = \$36{,}500 + 1{,}500k \quad (k = 1 \text{ to } 5)$

$n = 5$ years

$S = 85{,}000 - 10{,}000(6) = \$25{,}000$

11.8 Set up AW equations for 1 through 5 years and solve by hand.

For n=1: $\text{Total } AW_1 = -70{,}000(A/P,10\%,1) - 20{,}000 + 10{,}000(A/F,10\%,1)$
$= -70{,}000(1.10) - 20{,}000 + 10{,}000(1.0)$
$= \$\text{-}87{,}000$

For n=2: $\text{Total } AW_2 = -70{,}000(A/P,10\%,2) - 20{,}000 + 10{,}000(A/F,10\%,2)$
$= \$\text{-}55{,}571$

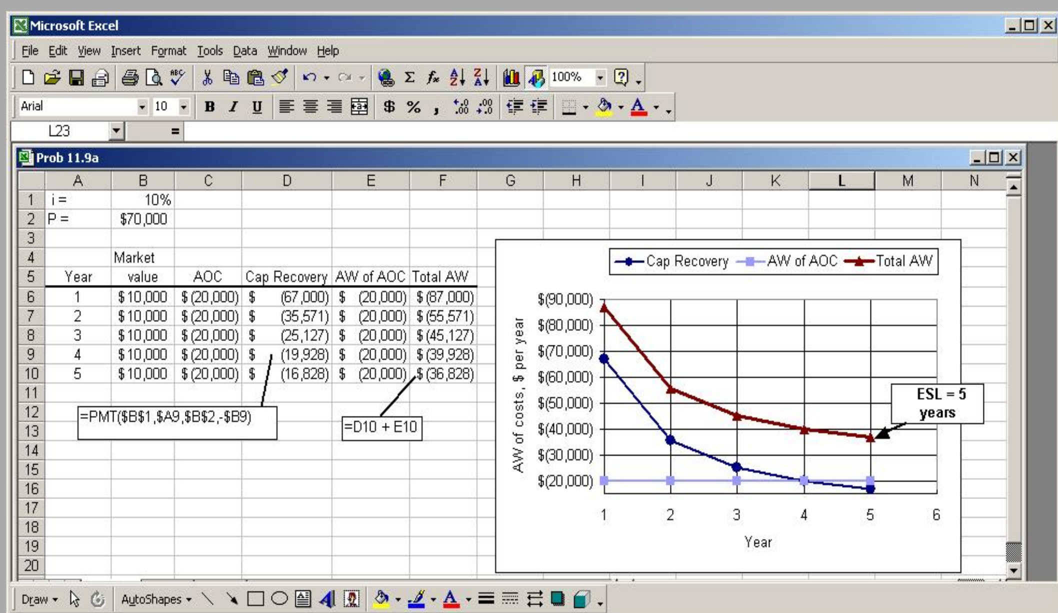
For n=3: Total AW_3 = \$-45,127

For n=4: Total AW_4 = \$-39,928

For n=5: Total AW_5 = \$-36,828

Economic service life is 5 years with Total AW_5 = \$-36,828

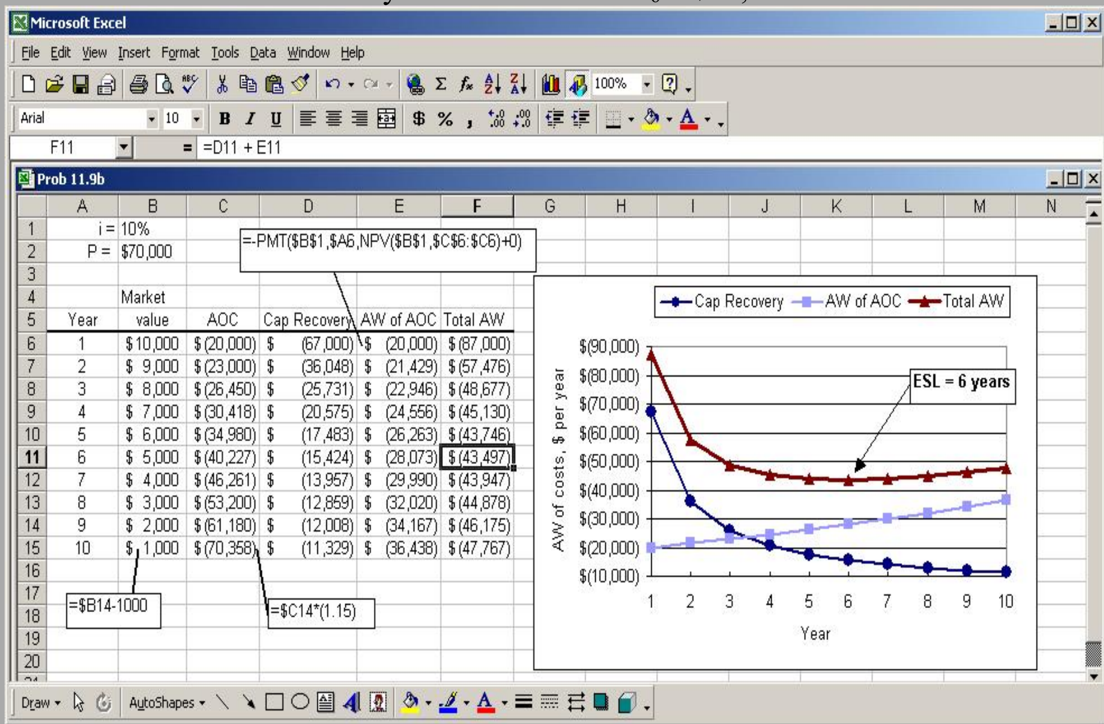
11.9 (a) Set up the spreadsheet using Figure 11-2 as a template and develop the cell formulas indicated in Figure 11-2 (a). The ESL is 5 years, as in Problem 11.8.



	A	B	C	D	E	F
1	i =	10%				
2	P =	\$70,000				
3						
4		Market				
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW
6	1	\$ 10,000	\$ (20,000)	\$ (67,000)	\$ (20,000)	\$ (87,000)
7	2	\$ 10,000	\$ (20,000)	\$ (35,571)	\$ (20,000)	\$ (55,571)
8	3	\$ 10,000	\$ (20,000)	\$ (25,127)	\$ (20,000)	\$ (45,127)
9	4	\$ 10,000	\$ (20,000)	\$ (19,928)	\$ (20,000)	\$ (39,928)
10	5	\$ 10,000	\$ (20,000)	\$ (16,828)	\$ (20,000)	\$ (36,828)

(b) On the same spreadsheet, decrease salvage by \$1000 each year, and increase AOC by 15% per year. Extend the years to 10. The ESL is relatively insensitive between years 5 and 7, but the conclusion is:

$$\text{ESL} = 6 \text{ years with Total } AW_6 = \$43{,}497$$



	i =	10%				
	P =	\$70,000				
		Market				
	Year	value	AOC	Cap Recovery	AW of AOC	Total AW
	1	\$ 10,000	\$ (20,000)	\$ (67,000)	\$ (20,000)	\$ (87,000)
	2	\$ 9,000	\$ (23,000)	\$ (36,048)	\$ (21,429)	\$ (57,476)
	3	\$ 8,000	\$ (26,450)	\$ (25,731)	\$ (22,946)	\$ (48,677)
	4	\$ 7,000	\$ (30,418)	\$ (20,575)	\$ (24,556)	\$ (45,130)
	5	\$ 6,000	\$ (34,980)	\$ (17,483)	\$ (26,263)	\$ (43,746)
	6	\$ 5,000	\$ (40,227)	\$ (15,424)	\$ (28,073)	\$ (43,497)
	7	\$ 4,000	\$ (46,261)	\$ (13,957)	\$ (29,990)	\$ (43,947)
	8	\$ 3,000	\$ (53,200)	\$ (12,859)	\$ (32,020)	\$ (44,878)
	9	\$ 2,000	\$ (61,180)	\$ (12,008)	\$ (34,167)	\$ (46,175)
	10	\$ 1,000	\$ (70,358)	\$ (11,329)	\$ (36,438)	\$ (47,767)

11.10 (a) Set up AW relations for each year.

For n = 1: $AW_1 = -250{,}000(A/P,4\%,1) - 25{,}000 + 225{,}000(A/F,4\%,1)$
$= \$-60{,}000$

For n = 2: $AW_2 = -250{,}000(A/P,4\%,2) - 25{,}000 + 200{,}000(A/F,4\%,2)$
$= \$-59{,}510$

For n = 3: $AW_3 = -250{,}000(A/P,4\%,3) - 25{,}000 + 175{,}000(A/F,4\%,3)$
$= \$-59{,}029$

For n = 4: $AW_4 = -250{,}000(A/P,4\%,4) - 25{,}000 + 150{,}000(A/F,4\%,4)$
$= \$-58{,}549$

For n = 5: $AW_5 = -250{,}000(A/P,4\%,5) - 25{,}000 + 125{,}000(A/F,4\%,5)$
$= \$-58{,}079$

For n = 6: $AW_6 = -250{,}000(A/P,4\%,6) - [25{,}000(P/A,4\%,5) + 25{,}000(1.25)(P/F,4\%,6)](A/P,4\%,6) + 100{,}000(A/F,4\%,6)$
$= \$-58{,}556$

AW values will increase, so ESL = 5 years with AW_5 = \$-58,079.

No, the ESL is not sensitive since AW values are within a percent or two of each other for values of n close to the ESL.

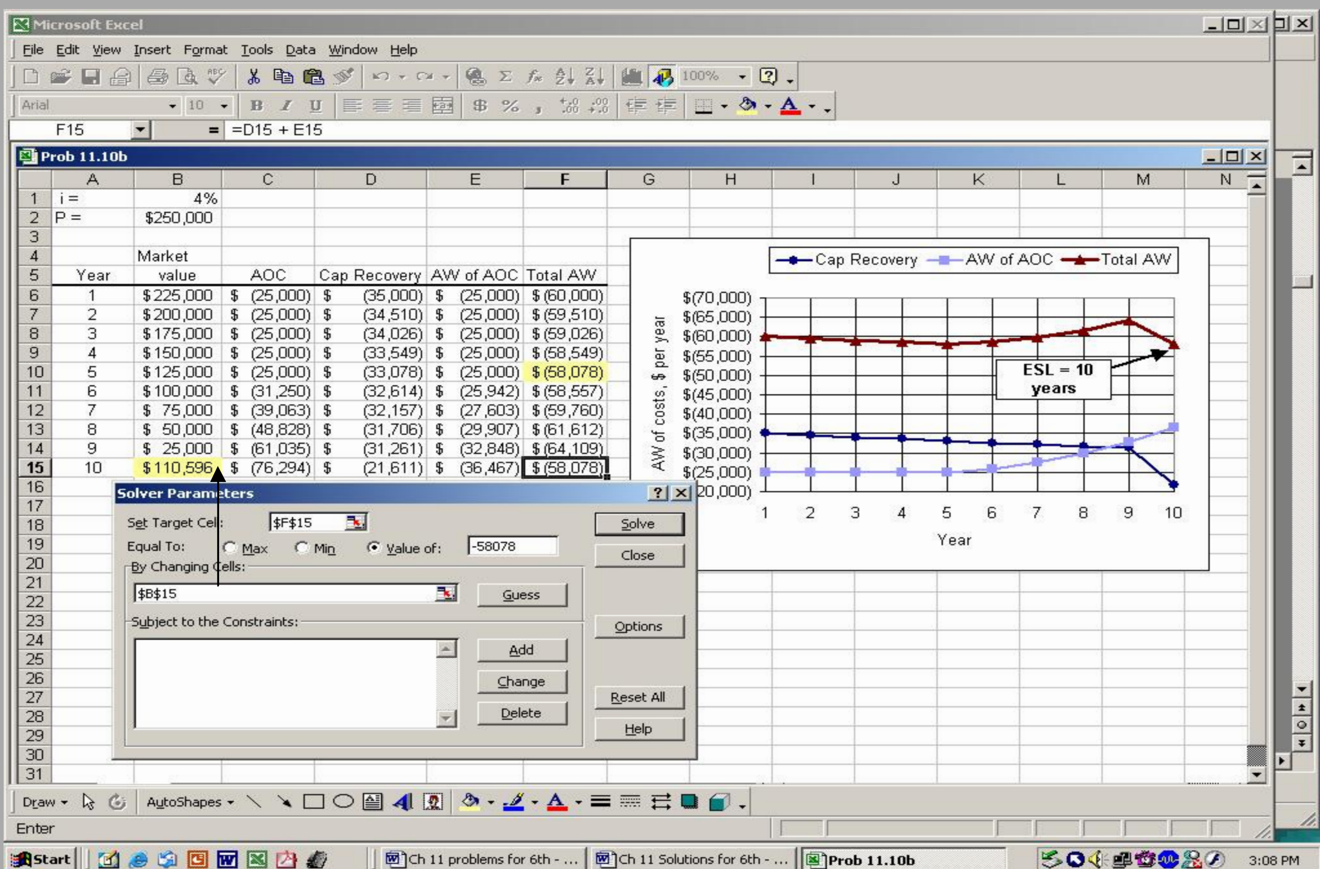
(b) For hand solution, set up the AW_{10} relation equal to AW_5 = \$-58,079 and an unknown MV_{10} value. The solution is MV_{10} = \$110,596.

$$AW_{10} = -250{,}000(A/P,4\%,10) - [25{,}000(P/A,4\%,5) + 31{,}250(P/F,4\%,6) + \ldots$$
$$+ 76{,}294(P/F,3\%,10)](A/P,4\%,10) + MV_{10}(A/P,4\%,10)$$
$$= \$-58{,}079$$

A fast solution is also to set up a spreadsheet and use SOLVER to find MV_{10} with $AW_{10} = AW_5$ = \$-58,079. Currently, AW_{10} = \$-67,290. The spreadsheet below shows the setup and chart. Target cell is F15 and changing cell is B15. Result is

Market value in year 10 must be at least \$110,596 to obtain ESL = 10 years.

11.10 (cont)



	A	B	C	D	E	F
1	i =	4%				
2	P =	\$250,000				
4		Market				
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW
6	1	\$225,000	\$ (25,000)	\$ (35,000)	\$ (25,000)	\$ (60,000)
7	2	\$200,000	\$ (25,000)	\$ (34,510)	\$ (25,000)	\$ (59,510)
8	3	\$175,000	\$ (25,000)	\$ (34,026)	\$ (25,000)	\$ (59,026)
9	4	\$150,000	\$ (25,000)	\$ (33,549)	\$ (25,000)	\$ (58,549)
10	5	\$125,000	\$ (25,000)	\$ (33,078)	\$ (25,000)	\$ (58,078)
11	6	\$100,000	\$ (31,250)	\$ (32,614)	\$ (25,942)	\$ (58,557)
12	7	\$ 75,000	\$ (39,063)	\$ (32,157)	\$ (27,603)	\$ (59,760)
13	8	\$ 50,000	\$ (48,828)	\$ (31,706)	\$ (29,907)	\$ (61,612)
14	9	\$ 25,000	\$ (61,035)	\$ (31,261)	\$ (32,848)	\$ (64,109)
15	10	\$110,596	\$ (76,294)	\$ (21,611)	\$ (36,467)	\$ (58,078)

11.11 (a) Set up AW equations for years 1 to 6 and solve by hand (or PMT function for spreadsheet solution) with P = \$100,000. Use the A/G factor for the gradient in the AOC series.

For n = 1: $AW_1 = -100{,}000(A/P,18\%,1) – 75{,}000 + 100{,}000(0.85)^1(A/F,18\%,1)$
$= \$ -108{,}000$

For n = 2: $AW_2 = -100{,}000(A/P,18\%,2) – 75{,}000 - 10{,}000(A/G,18\%,2)$
$+ 100{,}000(0.85)^2(A/F,18\%,2)$
$= \$ - 110{,}316$

For n = 3: $AW_3 = -100{,}000(A/P,18\%,3) – 75{,}000 - 10{,}000(A/G,18\%,3)$
$+ 100{,}000(0.85)^3 (A/F,18\%,3)$
$= \$ - 112{,}703$

For n = 4: $AW_4 = \$ - 115{,}112$

For n = 5: $AW_5 = \$ - 117{,}504$

For n= 6 $AW_6 = -100{,}000(A/P,18\%,6) – 75{,}000 - 10{,}000(A/G,18\%,6)$
$+ 100{,}000(0.85)^6 (A/F,18\%,6)$
$= \$ - 119{,}849$

ESL is 1 year with $AW_1 = \$-108{,}000$.

(b) Set the AW relation for year 6 equal to $AW_1 = \$-108{,}000$ and solve for P, the required lower first cost.

$AW_6 = -108{,}000 = -P(A/P,18\%,6) – 75{,}000 - 10{,}000(A/G,18\%,6)$
$+ P(0.85)^6(A/F,18\%,6)$

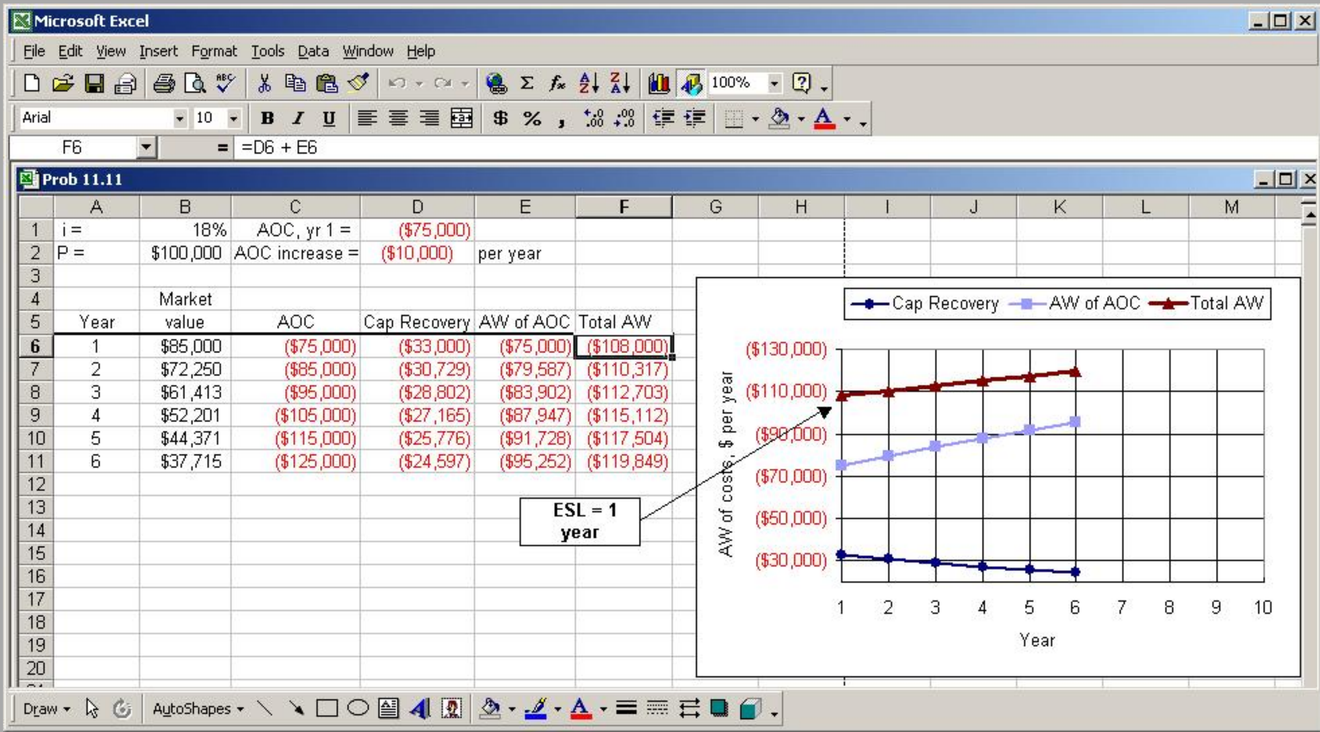
$-108{,}000 = -P(0.28591) – 75{,}000 – 10{,}000(2.0252) + P(0.37715)(0.10591)$

$0.24597P = -95{,}252 + 108{,}000$

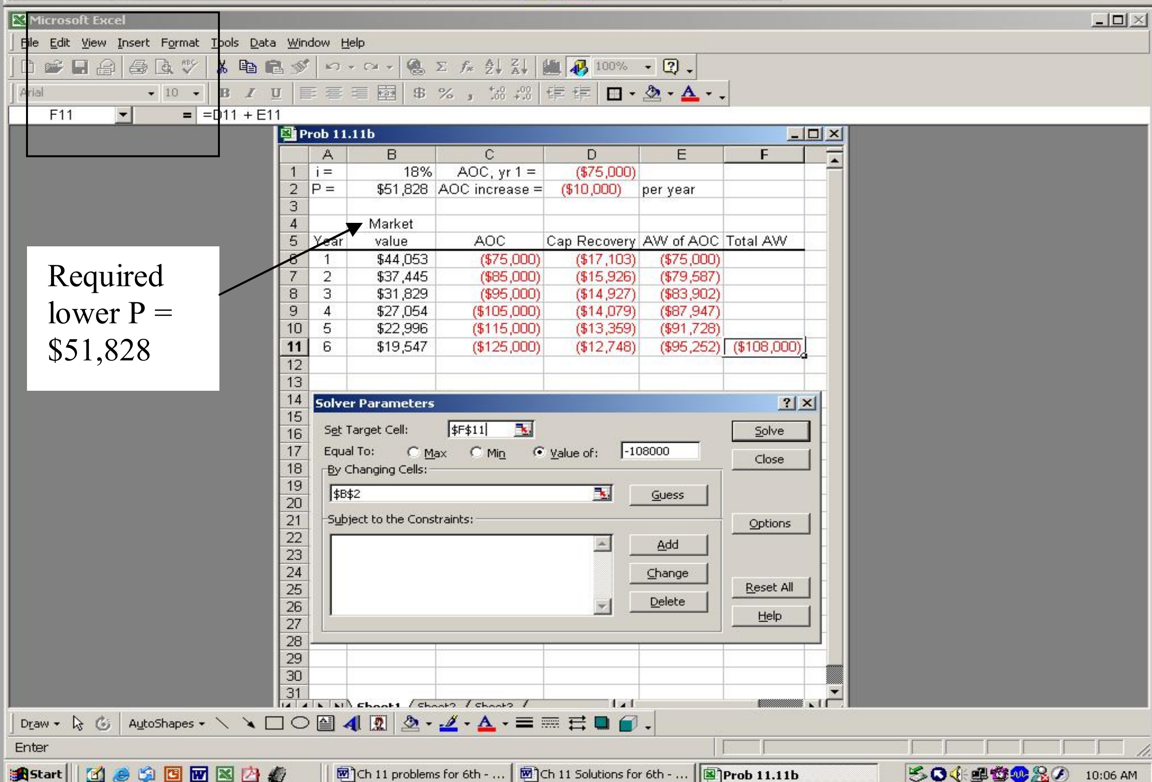
$P = \$51{,}828$

The first cost would have to be reduced from \$100,000 to \$51,828. This is a quite large reduction.

11.11 (cont) (a) and (b) Spreadsheets are shown below for (a) ESL = 1 year and $AW_1 = \$-108{,}000$, and (b) using SOLVER to find P = \$51,828.

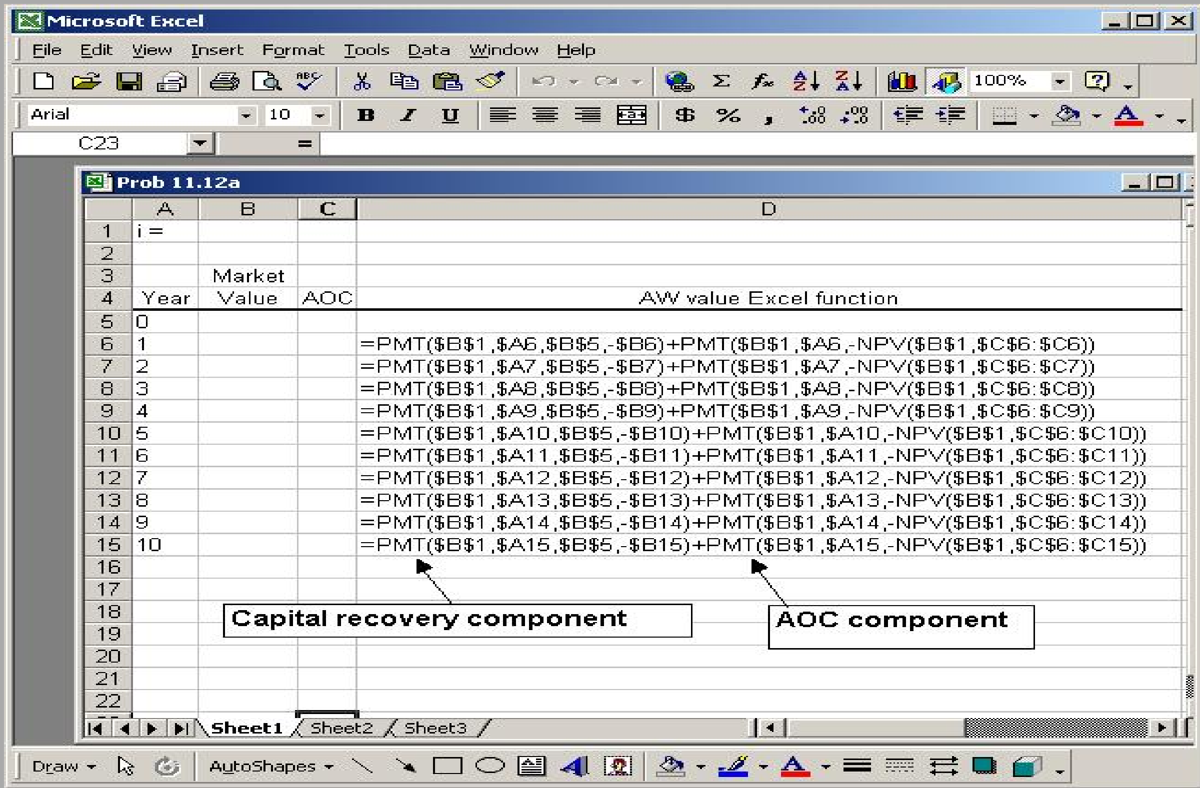


	A	B	C	D	E	F
1	i =	18%	AOC, yr 1 =	($75,000)		
2	P =	$100,000	AOC increase =	($10,000)	per year	
3						
4		Market				
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW
6	1	$85,000	($75,000)	($33,000)	($75,000)	($108,000)
7	2	$72,250	($85,000)	($30,729)	($79,587)	($110,317)
8	3	$61,413	($95,000)	($28,802)	($83,902)	($112,703)
9	4	$52,201	($105,000)	($27,165)	($87,947)	($115,112)
10	5	$44,371	($115,000)	($25,776)	($91,728)	($117,504)
11	6	$37,715	($125,000)	($24,597)	($95,252)	($119,849)



	A	B	C	D	E	F
1	i =	18%	AOC, yr 1 =	($75,000)		
2	P =	$51,828	AOC increase =	($10,000)	per year	
3						
4		Market				
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW
6	1	$44,053	($75,000)	($17,103)	($75,000)	
7	2	$37,445	($85,000)	($15,926)	($79,587)	
8	3	$31,829	($95,000)	($14,927)	($83,902)	
9	4	$27,054	($105,000)	($14,079)	($87,947)	
10	5	$22,996	($115,000)	($13,359)	($91,728)	
11	6	$19,547	($125,000)	($12,748)	($95,252)	($108,000)

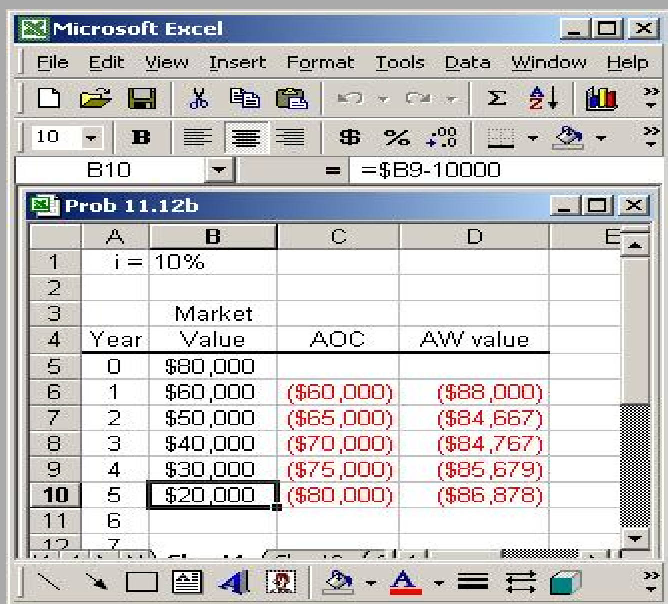
11.12 (a) Develop the cell relation for AW using the PMT function for the capital recovery component and AOC component. A general template may be:



Prob 11.12a

	A	B	C	D
1	i =			
2				
3		Market		
4	Year	Value	AOC	AW value Excel function
5	0			
6	1			=PMT($B$1,$A6,$B$5,-$B6)+PMT($B$1,$A6,-NPV($B$1,$C$6:$C6))
7	2			=PMT($B$1,$A7,$B$5,-$B7)+PMT($B$1,$A7,-NPV($B$1,$C$6:$C7))
8	3			=PMT($B$1,$A8,$B$5,-$B8)+PMT($B$1,$A8,-NPV($B$1,$C$6:$C8))
9	4			=PMT($B$1,$A9,$B$5,-$B9)+PMT($B$1,$A9,-NPV($B$1,$C$6:$C9))
10	5			=PMT($B$1,$A10,$B$5,-$B10)+PMT($B$1,$A10,-NPV($B$1,$C$6:$C10))
11	6			=PMT($B$1,$A11,$B$5,-$B11)+PMT($B$1,$A11,-NPV($B$1,$C$6:$C11))
12	7			=PMT($B$1,$A12,$B$5,-$B12)+PMT($B$1,$A12,-NPV($B$1,$C$6:$C12))
13	8			=PMT($B$1,$A13,$B$5,-$B13)+PMT($B$1,$A13,-NPV($B$1,$C$6:$C13))
14	9			=PMT($B$1,$A14,$B$5,-$B14)+PMT($B$1,$A14,-NPV($B$1,$C$6:$C14))
15	10			=PMT($B$1,$A15,$B$5,-$B15)+PMT($B$1,$A15,-NPV($B$1,$C$6:$C15))

(b) Insert the MV and AOC series and i = 10% to obtain the answer ESL = 2 years with AW_2 = $-84,667.



Prob 11.12b

B10 = =$B9-10000

	A	B	C	D
1	i =	10%		
2				
3		Market		
4	Year	Value	AOC	AW value
5	0	$80,000		
6	1	$60,000	($60,000)	($88,000)
7	2	$50,000	($65,000)	($84,667)
8	3	$40,000	($70,000)	($84,767)
9	4	$30,000	($75,000)	($85,679)
10	5	$20,000	($80,000)	($86,878)
11	6			

For hand solution, the AW relation for n = 2 years is:

$$AW_2 = \$-80,000(A/P,10\%,2) – 60,000 - 5000(A/G,10\%,2) + 50,000(A/F,10\%,2)$$
$$= \$-84,667$$

11.13 (a) Solution by hand using regular AW computations.

Year	Salvage Value, $	AOC, $
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

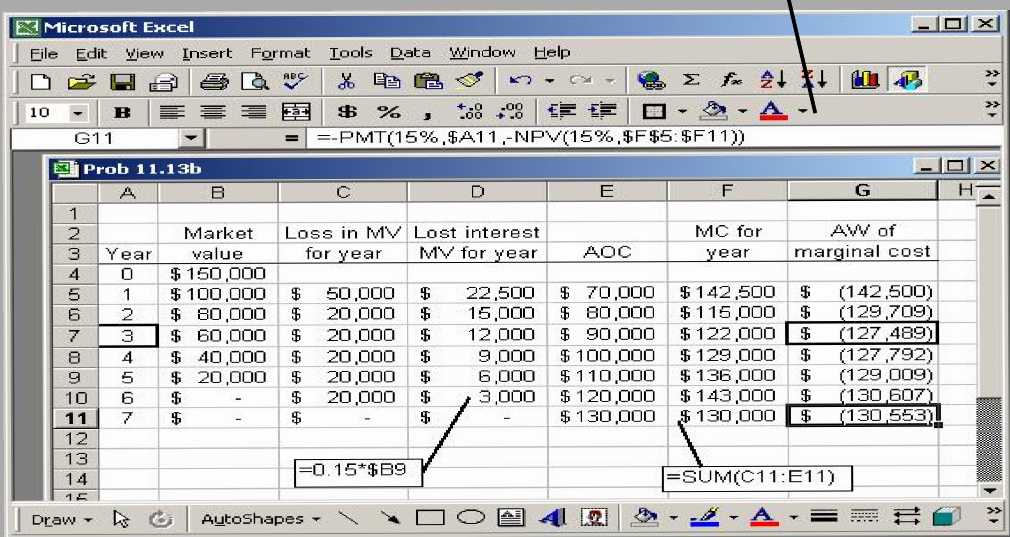
AW_1 = -150,000(A/P,15%,1) – 70,000 + 100,000(A/F,15%,1)
= $-142,500

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 below utilizes the annual marginal costs to determine that ESL is 3 years with AW = $-127,489.



Year	Market value	Loss in MV for year	Lost interest MV for year	AOC	MC for year	AW of marginal cost
0	$ 150,000					
1	$ 100,000	$ 50,000	$ 22,500	$ 70,000	$ 142,500	$ (142,500)
2	$ 80,000	$ 20,000	$ 15,000	$ 80,000	$ 115,000	$ (129,709)
3	$ 60,000	$ 20,000	$ 12,000	$ 90,000	$ 122,000	$ (127,489)
4	$ 40,000	$ 20,000	$ 9,000	$ 100,000	$ 129,000	$ (127,792)
5	$ 20,000	$ 20,000	$ 6,000	$ 110,000	$ 136,000	$ (129,009)
6	$ -	$ 20,000	$ 3,000	$ 120,000	$ 143,000	$ (130,607)
7	$ -	$ -	$ -	$ 130,000	$ 130,000	$ (130,553)

11.14 Set up AW equations for n = 1 through 7 and solve by hand.

For n = 1: $AW_1 = -100{,}000(A/P,14\%,1) - 28{,}000 + 75{,}000(A/F,14\%,1)$
$= \$-67{,}000$

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

For n = 3: $AW_3 = \$-59{,}275$

For n = 4: $AW_4 = \$-57{,}594$

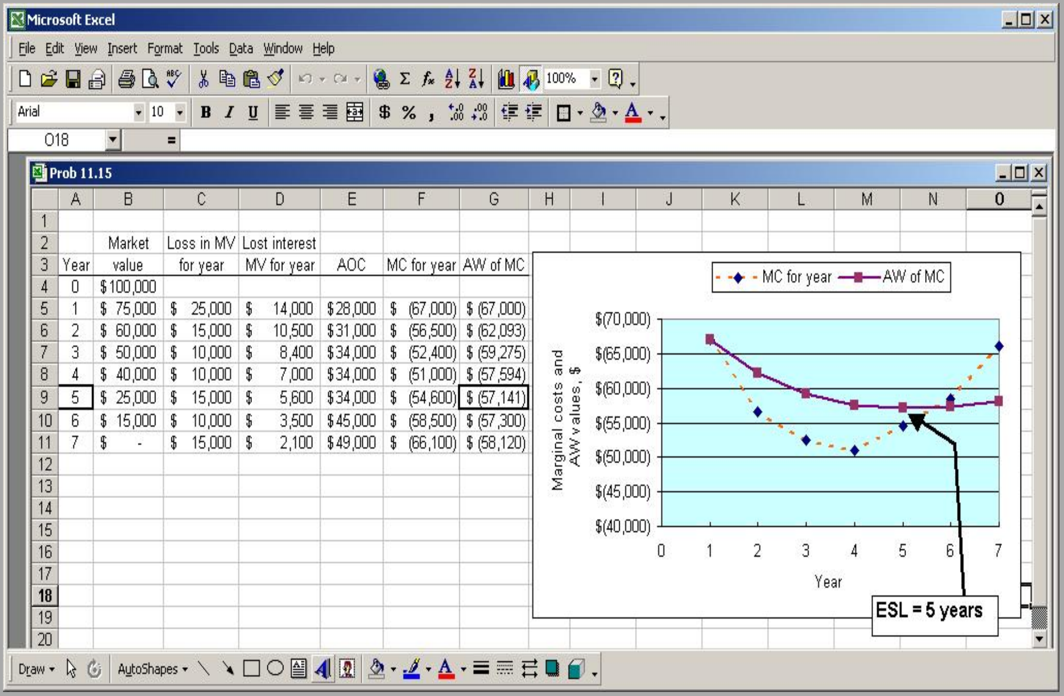
For n = 5: $AW_5 = \$-57{,}141$

For n = 6 $AW_6 = \$-57{,}300$

For n = 7: $AW_7 = \$-58{,}120$

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

11.15 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)

11.16 (a) Year 200X: Select defender for 3 year retention at AW_D = \$-10,000
Year 200X+1: Select defender for 1 year retention at AW_D = \$-14,000
Year 200X+2: Select challenger 2 for 3 year retention at AW_{C2} = \$-9,000

(b) Changes during year 200X+1: Defender estimates changed to reduce ESL and increase AW_D
Changes during year 200X+2: New challenger C2 has lower AW and shorter ESL than C1.

11.17 Defender: ESL = 3 years with AW_D = \$-47,000
Challenger: ESL = 2 years with AW_C = \$-49,000

Recommendation now is to retain the defender for 3 years, then replace.

11.18 Step 2 is applied (section 11.3, which leads to step 3. Use the estimates to determine the ESL and AW for the new challenger. If defender estimates changed, calculate their new ESL and AW values. Select the better of D or C (step 1).

11.19 $AW_D = -(50{,}000 + 200{,}000)\,(A/P,12\%,3) + 40{,}000(A/F,12\%,3)$
$= -250{,}000(0.41635) + 40{,}000(0.29635)$
$= \$-92{,}234$

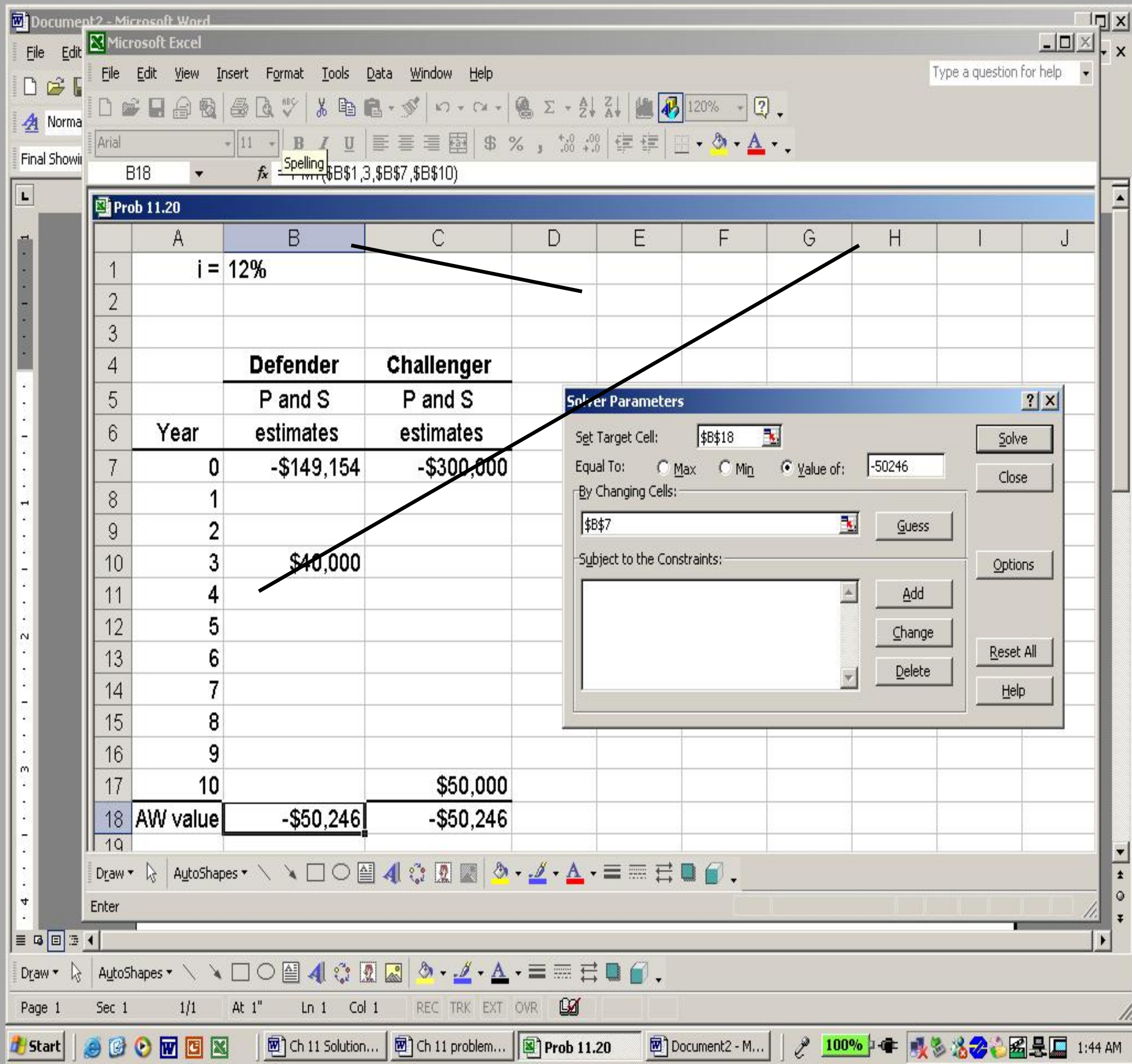
$AW_C = -300{,}000(A/P,12\%,10) + 50{,}000(A/F,12\%,10)$
$= -300{,}000(0.17698) + 50{,}000(0.05698)$
$= \$-50{,}245$

Purchase the challenger and plan to keep then for 10 years, unless a better challenger is evaluated in the future.

11.20 Set up the spreadsheet and use SOLVER 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 = 149,154 – 50,000 = \$99,154

This is a maximum; any amount less than \$99,154 will indicate selection of the upgraded current system.



11.21 (a) The n values are set; calculate the AW values directly and select D or C.

$$AW_D = -50{,}000(A/P,10\%,5) - 160{,}000 = -50{,}000(0.26380) - 160{,}000 = \$-173{,}190$$

$$AW_C = -700{,}000(A/P,10\%,10) - 150{,}000 + 50{,}000(A/F,10\%,10) = -700{,}000(0.16275) - 150{,}000 + 50{,}000(0.06275) = \$-260{,}788$$

Retain the current bleaching system for 5 more years.

(b) Find the replacement value for the current process.

$$-RV(A/P,10\%,5) - 160{,}000 = AW_C = -260{,}788$$

$$-0.26380\ RV = -100{,}788$$

$$RV = \$382{,}060$$

This is 85% of the first cost 7 years ago; way too high for a trade-in value now.

11.22 (a) Find the ESL for a current vehicle. Subscripts are D1 and D2.

For n = 1: $AW_D = -(8000 + 50{,}000)(A/P,10\%,1) – 10{,}000$
$= -58{,}000(1.10) – 10{,}000$
$= \$-73{,}800$

For n = 2: $AW_D = -(8000 + 50{,}000)(A/P,10\%,2) – 10{,}000 - 5000(A/F,10\%,2)$
$= -58{,}000(0.57619) – 10{,}000 – 5000(0.47619)$
$= \$-45{,}800$

The defender ESL is 2 years with $AW_D = \$-45{,}800$.

$AW_C = \$-55{,}540$

Spend the \$50,000 and keep the current vehicles for 2 more years.

(b) Add a salvage value term to $AW_C = \$-55{,}540$, set equal to AW_D and find S.

$AW_D = -45{,}800 = -55{,}540 + S(A/F,10\%,7)$

$S = -9740/0.10541 = \$92{,}401$

Any $S \geq \$92{,}401$ will indicate replacement now.

11.23 **Life-based** conclusions with associated AW value (in \$1000 units) based on estimated n value.

Study conducted this many years ago	Alternative selected: Defender AW value	Alternative selected: Challenger AW value	
6		Selected	\$-130
4		Selected	\$-120
2		Selected	\$-130
Now		Selected	\$- 80

ESL-based conclusions with associated AW value (in \$1000 units) based on ESL

Study conducted this many years ago	Alternative selected			
	Defender AW value		Challenger AW value	
6			Selected	$- 80
4	Selected	$- 80		
2	Selected	$- 80		
Now			Selected	$- 80

The decisions are different in that the defender is selected 4 and 2 years ago. Also, the AW values are significantly lower for the ESL-based analysis. In conclusion, the AW values for the ESLs should have been used to perform all the replacement studies.

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

For n = 1: AW_D = -8000(A/P,15%,1) – 50,000 + 6000(A/F,15%,1)
= -8000(1.15) – 44,000
= $-53,200

For n = 2: AW_D = -8000(A/P,15%,2) – 50,000 + (-3000 + 4000)(A/F,15%,2)
= -8000 (0.61512) – 50,000 + 1000(0.46512)
= $-54,456

For n = 3: AW_D = -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

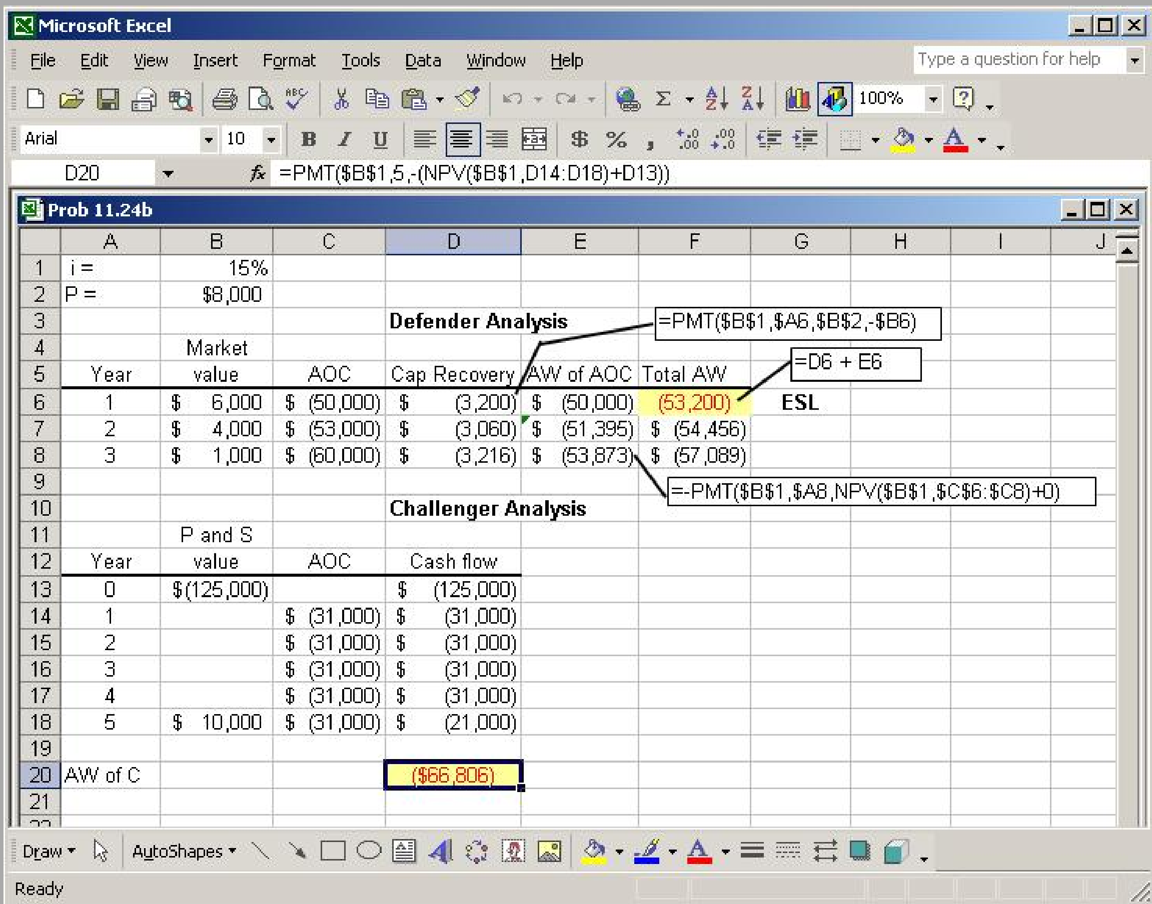
The ESL is now 1 year with AW_D = $-53,200

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 value is lower that the challenger AW, Richter should keep the defender now and replace it after 1 year.

11.24 (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
AW_C = \$-66,806
Select the defender now and replaced after one year.



	A	B	C	D	E	F	G
1	i =	15%					
2	P =	$8,000					
3				Defender Analysis			
4		Market					
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW	
6	1	$ 6,000	$ (50,000)	$ (3,200)	$ (50,000)	(53,200)	ESL
7	2	$ 4,000	$ (53,000)	$ (3,060)	$ (51,395)	$ (54,456)	
8	3	$ 1,000	$ (60,000)	$ (3,216)	$ (53,873)	$ (57,089)	
9							
10				Challenger Analysis			
11		P and S					
12	Year	value	AOC	Cash flow			
13	0	$(125,000)		$ (125,000)			
14	1		$ (31,000)	$ (31,000)			
15	2		$ (31,000)	$ (31,000)			
16	3		$ (31,000)	$ (31,000)			
17	4		$ (31,000)	$ (31,000)			
18	5	$ 10,000	$ (31,000)	$ (21,000)			
19							
20	AW of C			($66,806)			
21							

11.25 The opportunity cost refers to the recognition that the trade in value of the defender is foregone when this asset is retained in a replacement study.

11.26 The cash flow approach will only yield the proper decision when the defender and challenger have the same lives. Also, the cash flow approach does not properly reflect the amount needed to recover the initial investment, because the value used for the first cost of the challenger, P_C = first cost – market value of defender, is lower than it should be from a capital recovery perspective.

11.27 (a) By hand: Find the replacement value (RV) for the in-place system.

$$-RV(A/P,12\%,7) – 75{,}000 + 50{,}000(A/F,12\%,7) = -400{,}000(A/P,12\%,12) – 50{,}000 + 35{,}000(A/F,12\%,12)$$

$$-RV(0.21912) – 75{,}000 + 50{,}000(0.09912) = -400{,}000(0.16144) – 50{,}000 + 35{,}000(0.04144)$$

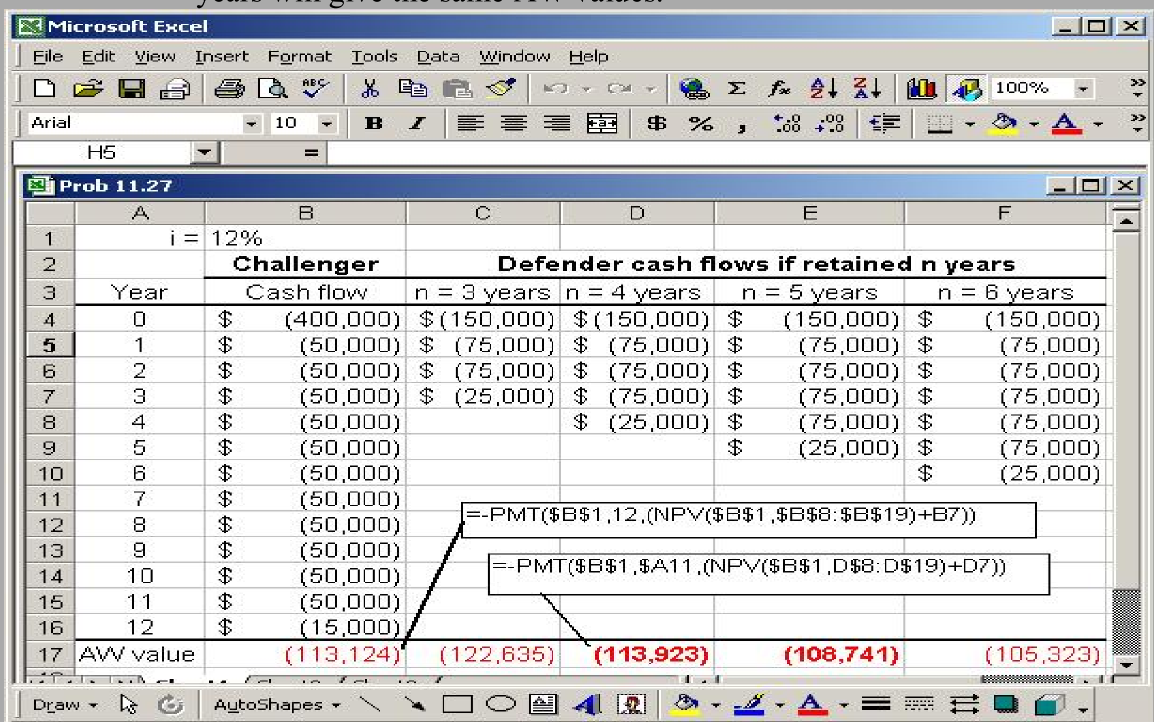
$$-0.21912\ RV – 75{,}000 + 50{,}000(0.09912) = -113{,}126$$
$$-0.21912\ RV = -43{,}082$$
$$RV = \$196{,}612$$

(b) By hand: Solve the AW_D relation for different n values until it equals $AW_C = -\$113{,}126$

For n = 3: $-150{,}000(A/P,12\%,3) – 75{,}000 + 50{,}000(A/F,12\%,3) = -\$-122{,}635$
For n = 4: $-150{,}000(A/P,12\%,4) – 75{,}000 + 50{,}000(A/F,12\%,4) = -\$-113{,}923$
For n = 5: $-150{,}000(A/P,12\%,5) – 75{,}000 + 50{,}000(A/F,12\%,5) = -\$-108{,}741$

Retain the defender just over 4 years.

By spreadsheet: One approach is to set up the defender cash flows for increasing n values and use the PMT function to find AW. Just over 4 years will give the same AW values.



	A	B	C	D	E	F
1	i =	12%				
2		Challenger	Defender cash flows if retained n years			
3	Year	Cash flow	n = 3 years	n = 4 years	n = 5 years	n = 6 years
4	0	$ (400,000)	$ (150,000)	$ (150,000)	$ (150,000)	$ (150,000)
5	1	$ (50,000)	$ (75,000)	$ (75,000)	$ (75,000)	$ (75,000)
6	2	$ (50,000)	$ (75,000)	$ (75,000)	$ (75,000)	$ (75,000)
7	3	$ (50,000)	$ (25,000)	$ (75,000)	$ (75,000)	$ (75,000)
8	4	$ (50,000)		$ (25,000)	$ (75,000)	$ (75,000)
9	5	$ (50,000)			$ (25,000)	$ (75,000)
10	6	$ (50,000)				$ (25,000)
11	7	$ (50,000)				
12	8	$ (50,000)				
13	9	$ (50,000)				
14	10	$ (50,000)				
15	11	$ (50,000)				
16	12	$ (15,000)				
17	AW value	(113,124)	(122,635)	(113,923)	(108,741)	(105,323)

=-PMT($B$1,12,(NPV($B$1,$B$8:$B$19)+B7))
=-PMT($B$1,$A11,(NPV($B$1,D$8:D$19)+D7))

11.28 Determine ESL of defender and challenger and then decide how long to keep defender.

<u>Defender ESL analysis for 1, 2 and 3 years:</u>

For n = 1: AW_D = -20,000(A/P,15%,1) – 50,000 + 10,000
= -20,000(1.15) – 40,000
= $-63,000

For n = 2: AW_D = -20,000(A/P,15%,2) – 50,000 – 10,000(A/G,15%,2) + 6000(A/F,15%,2)
= -20,000(0.61512) – 50,000 – 10,000(0.4651) + 6,000(0.46512)
= $-64,163

For n = 3: AW_D = -20,000(A/P,15%,3) - 50,000 – 10,000(A/G,15%,3) + 2000(A/F,15%,3)
= -20,000(0.43798) - 50,000 - 10,000(0.9071) + 2,000(0.28798)
= $-67,255

Defender ESL is 1 year with AW_D = $-63,000

<u>Challenger ESL analysis for 1 through 6 years:</u>

For n = 1: AW_C = -150,000(A/P15%,1) – 10,000 + 65,000
= -150,000(1.15) + 55,000
= $-117,500

For n = 2: AW_C = -150,000(A/P,15%,2) –10,000 – 4,000(A/G,15%,2) + 45,000(A/F,15%,2)
= $-83,198

For n = 3: AW_C = -150,000(A/P,15%,3) –10,000 – 4,000(A/G,15%,3) + 25,000(A/F,15%,3)
= $-72,126

For n = 4: AW_C = -150,000(A/P,15%,4) - 10,000 - 4,000(A/G,15%,4) + 5,000(A/F,15%,4)
= $-66,844

For n = 5: AW_C = -[150,000 + 10,000(P/A,15%,5) + 4,000(P/G,15%,5) + 40,000(P/F,15%,5)](A/P,15%,5)
= $- 67,573

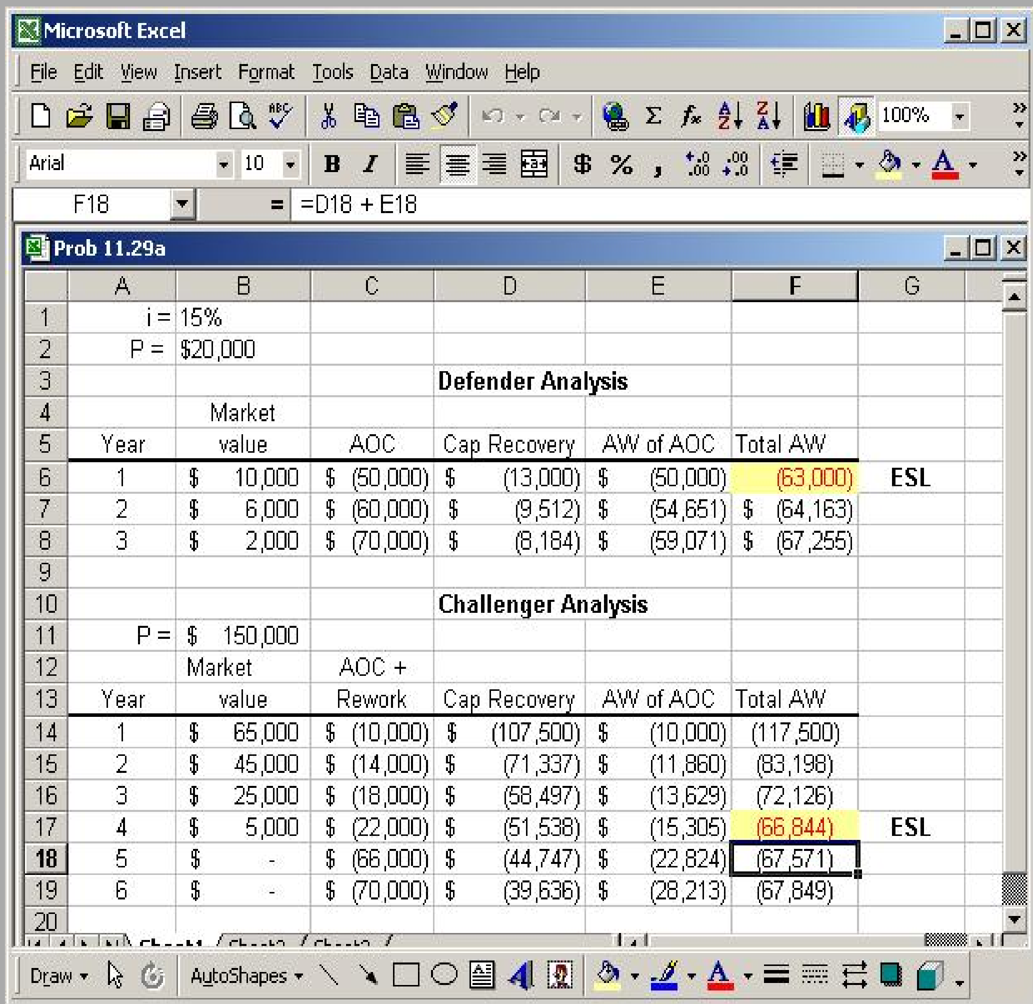
For n = 6: AW_C = -[150,000 + 10,000(P/A,15%,6) + 4,000(P/G,15%,6) + 40,000[(P/F,15%,5) + (P/F,15%,6]](A/P,15%,6)
= $-67,849

11.28 (cont)

Challenger ESL is 4 years with AW_C = $-66,844

Conclusion: Keep the defender 1 more year at AW_D = $-63,000, then replace for 4 years at AW_C = $-66,844, provided there are no changes in the challenger's estimates during the year the defender is retained.

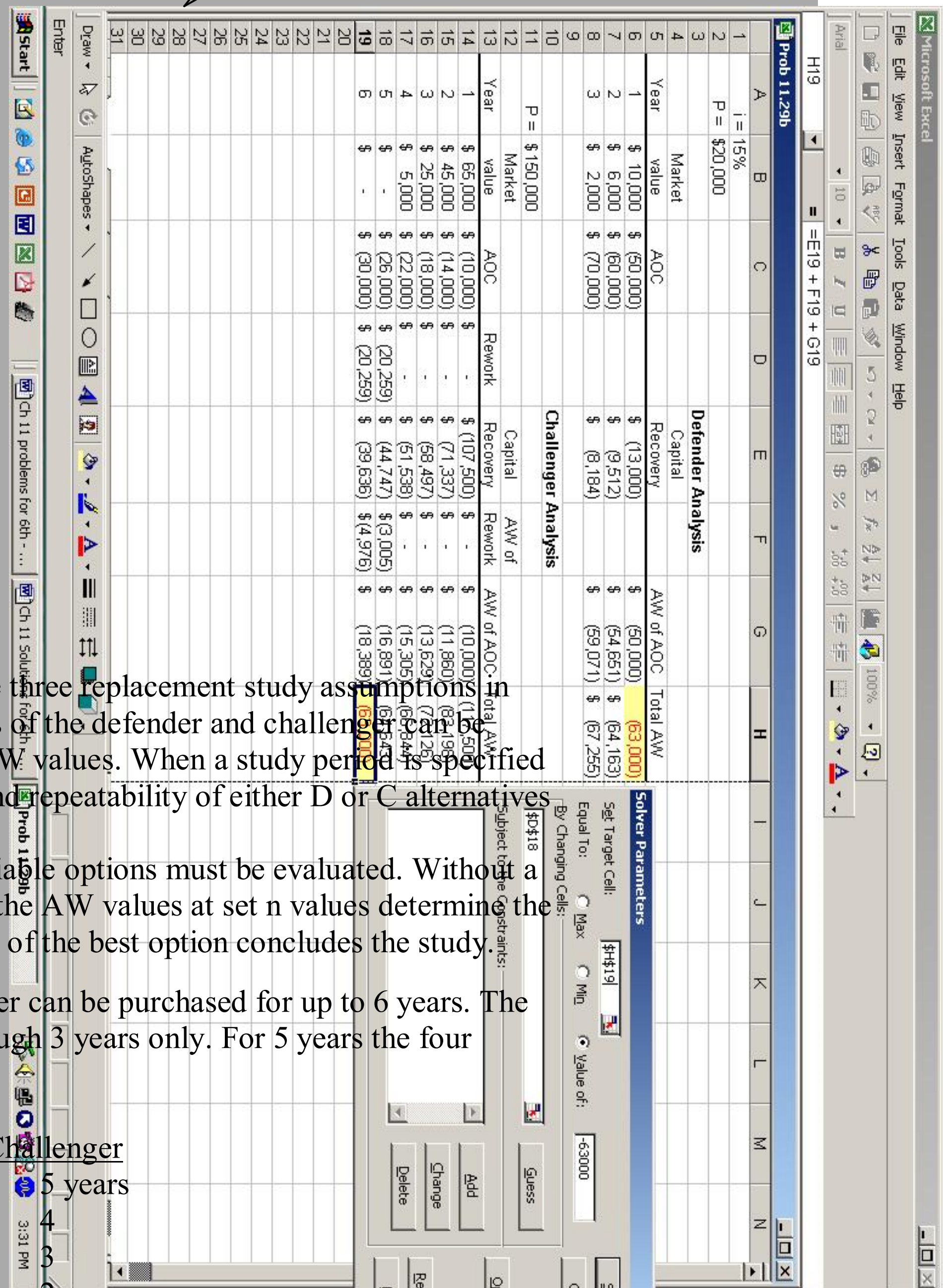
11.29 (a) Set up a spreadsheet (like that in Example 11.2) to find both ESL and their AW values.



	A	B	C	D	E	F	G
1	i =	15%					
2	P =	$20,000					
3				Defender Analysis			
4		Market					
5	Year	value	AOC	Cap Recovery	AW of AOC	Total AW	
6	1	$ 10,000	$ (50,000)	$ (13,000)	$ (50,000)	(63,000)	ESL
7	2	$ 6,000	$ (60,000)	$ (9,512)	$ (54,651)	$ (64,163)	
8	3	$ 2,000	$ (70,000)	$ (8,184)	$ (59,071)	$ (67,255)	
9							
10				Challenger Analysis			
11	P =	$ 150,000					
12		Market	AOC +				
13	Year	value	Rework	Cap Recovery	AW of AOC	Total AW	
14	1	$ 65,000	$ (10,000)	$ (107,500)	$ (10,000)	(117,500)	
15	2	$ 45,000	$ (14,000)	$ (71,337)	$ (11,860)	(83,198)	
16	3	$ 25,000	$ (18,000)	$ (58,497)	$ (13,629)	(72,126)	
17	4	$ 5,000	$ (22,000)	$ (51,538)	$ (15,305)	(66,844)	ESL
18	5	$ -	$ (66,000)	$ (44,747)	$ (22,824)	(67,571)	
19	6	$ -	$ (70,000)	$ (39,636)	$ (28,213)	(67,849)	
20							

11.29 (cont) (b) Develop separate columns for AOC and rework costs of $40,000 in years 5 and 6. Use SOLVER to force AW_C to equal $-63,000 in year 6 (target cell is H19). Rework cost allowed is $20,259 (changing cell is D18), which is about half of the projected $40,000 estimate.

Impact: For all values of rework less than $20,259, the replacement study will indicate selection of the challenger for the next 6 years and disposal of the defender this year.



11.30 (a) If no study period is specified, the three replacement study assumptions in Section 11.1 hold. So, the services of the defender and challenger can be obtained (it is assumed) at their AW values. When a study period is specified these assumptions are not made and repeatability of either D or C alternatives is not a consideration.

(b) If a study period is specified, all viable options must be evaluated. Without a study period, the ESL analysis or the AW values at set n values determine the AW values for D and C. Selection of the best option concludes the study.

11.31 (a) Develop the options first. Challenger can be purchased for up to 6 years. The defender can be retained for 0 through 3 years only. For 5 years the four options are:

Options	Defender	Challenger
A	0 years	5 years
B	1	4
C	2	3
D	3	2

Defender and challenger AW values (as taken from Problem 11.28 or 11.29(a) spreadsheet).

Years in service	Defender AW value	Challenger AW value
1	$-63,000	$-117,500
2	-64,163	-83,198
3	-67,255	-72,126
4	-	-66,844
5	-	-67,571

Determine the equivalent cash flows for 5 years for each option and calculate PW values.

	Years in service		Equivalent Cash Flow, AW $ per year					
Option	D	C	1	2	3	4	5	PW, $
A	0	5	-67,571	-67,571	-67,571	-67,571	-67,571	-226,508
B	1	4	-63,000	-66,844	-66,844	-66,844	-66,844	-220,729
C	2	3	-64,163	-64,163	-72,126	-72,126	-72,126	-228,832
D	3	2	-67,255	-67,255	-67,255	-83,198	-83,198	-242,491

Select option B (smaller PW of costs); retain defender for 1 year then replace with the challenger for 4 years.

(b) There are four options since the defender can be retained up to three years.

Options	Defender	Challenger Contract
E	0 years	5 years
F	1	4
G	2	3
H	3	2

Determine the equivalent cash flows for 5 years for each option and calculate PW values

	Years		Equivalent Cash Flow, AW $ per year					
Option	D	C	1	2	3	4	5	PW, $
A	0	5	-85,000	- 85,000	- 85,000	- 85,000	- 85,000	-284,933
B	1	4	-63,000	- 85,000	- 85,000	- 85,000	- 85,000	-265,803
C	2	3	-64,163	- 64,163	-100,000	-100,000	-100,000	-276,955
D	3	2	-67,255	- 67,255	- 67,255	-100,000	-100,000	-260,451

Select option D (smaller PW of costs); retain defender for 3 years then replace with the full-service contract for 2 years.

11.32 Study period is 3 years. Three options are viable: defender for 2 more years, challenger for 1; defender 1 year, challenger for 2 years; and, challenger for 3 years. Find the AW values and select the best option.

<u>1. Defender 2 years, challenger 1 year:</u>

AW = -200,000 – (300,000 – 200,000)(A/F,18%,3)

= -200,000 – 100,000 (0.27992)
= $-227,992

<u>2. Defender 1 year, challenger 2 years</u>

AW = [-200,000(P/F,18%,1) + 225,000(P/A,18%,2)(P/F,18%,1)](A/P,18%,3)
=[-200,000(0.8475) + 225,000(1.5656)(0.8475)](0.45992)
= $-215,261

<u>3. Challenger for 3 years</u>

AW = $-275,000

Decision: Replace the defender after 1 year.

11.33 (a)

Option	Defender	Challenger
1	0	5
2	0	6
3	0	7
4	0	8
5	3	2
6	3	3
7	3	4
8	3	5

Microsoft Excel — Prob 11.33

i = 10%

Option	Years D	Years C	1	2	3	4	5	6	7	8	PW	AW
			Cash flow for different study period lengths, $ per year									
1	0	5	-90,000	-90,000	-90,000	-90,000	-90,000				($341,171)	($90,000)
2	0	6	-110000	-110000	-110000	-110000	-110000	-110000			($479,079)	($110,000)
3	0	7	-110000	-110000	-110000	-110000	-110000	-110000	-110000		($535,526)	($110,000)
4	0	8	-110000	-110000	-110000	-110000	-110000	-110000	-110000	-110000	($586,842)	($110,000)
5	3	2	-90,000	-90,000	-90,000	-90,000	-90,000				($341,171)	($90,000)
6	3	3	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000			($391,973)	($90,000)
7	3	4	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000		($438,158)	($90,000)
8	3	5	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000	-90,000	($480,143)	($90,000)

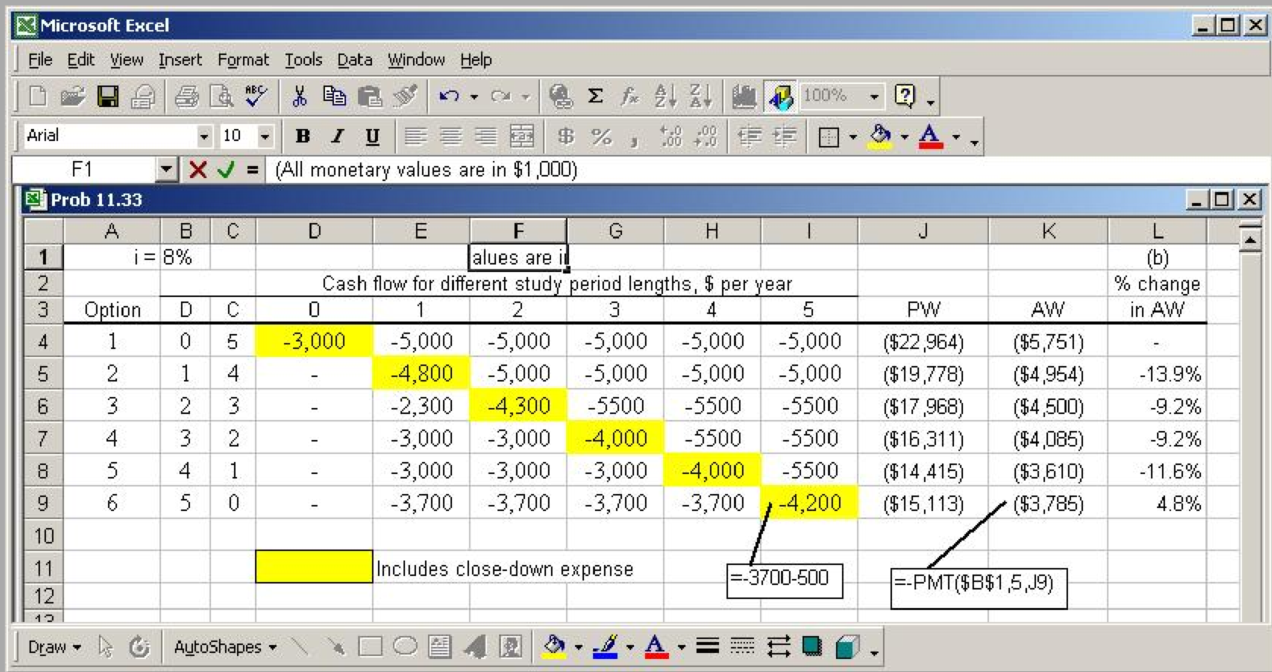
=-PMT($B$1,$B11+$C11,L11)

A total of 5 options have AW = $-90,000. Several ways to go; defender can be replaced now or after 3 years and challenger can be used from 2 to 5 years, depending on the option chosen.

(b) PW values cannot be used to select best options since the equal-service assumption is violated due to study periods of different lengths. Must us AW values.

11.34 (a) There are 6 options. Spreadsheet 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 for years in effect. The most economic is:

Select option 5; retain current system for 4 years; purchase contract for the 5th year only at $5,500,000, assuming the contract cost remains as quoted now. Estimated AW = $-3.61 million per year



	A	B	C	D	E	F	G	H	I	J	K	L
1	i =	8%				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)		

(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.

11.35 There are only two options: defender for 3, challenger for 2 years; defender for 0, challenger for 5. Defender has a market value of $40,000 now

<u>Defender</u> For n = 3:

$$
\begin{aligned}
AW_D &= -(70{,}000 + 40{,}000)(A/P,20\%,3) - 85{,}000 \\
&= -110{,}000(0.47473) - 85{,}000 \\
&= \$-137{,}220
\end{aligned}
$$

Challenger

For n = 2: AW_C = -220,000(A/P,20%,2) – 65,000 + 50,000(A/F,20%,2)
= -220,000(0.65455) – 65,000 + 50,000(0.45455)
= $-186,274

For n = 3: AW_C = $-155,703

For n = 4: AW_C = $-140,669

For n = 5: AW_C = -220,000(A/P,20%,5) – 65,000 + 50,000(A/F,20%,5)
= -220,000(0.33438) – 65,00 + 50,000(0.13438)
= $-131,845

The challenger AW = $-131,845 for 5 years of service is lower than that of the defender. By inspection, the defender should be replaced now. The AW for each option can be calculated to confirm this.

Option 1: defender 3 years, challenger 2 years

AW = [-137,220(P/A,20%,3) – 186,274(P/A,20%,2)(P/F, 20%, 3)](A/P,20%,5)
= $-151,726

Option 2: defender replaced now, challenger for 5 years

AW = $-131,845

Again, replace the defender with the challenger now.

FE Review Solutions

11.36 Answer is (a)

11.37 Answer is (d)

11.38 Answer is (c)

11.39 Answer is (c)

11.40 Answer is (b)

Extended Exercise Solution

The three spreadsheets below answer the three questions.

1. The ESL is 13 years.

Ext Exercise Solution - #1. Find the ESL

Year	First cost & rebuild cost	AOC	Capital recovery	AW of AOC and rebuild	Total AW	
0	$ (800,000)					
1	$ -	$ (25,000)	$ (880,000)	$ (25,000)	$(905,000)	
2	$ -	$ (25,000)	$ (460,952)	$ (25,000)	$(485,952)	
3	$ -	$ (25,000)	$ (321,692)	$ (25,000)	$(346,692)	
4	$ (150,000)	$ (25,000)	$ (252,377)	$ (57,321)	$(309,697)	
5	$ -	$ (40,000)	$ (211,038)	$ (54,484)	$(265,522)	
6	$ -	$ (46,000)	$ (183,686)	$ (53,384)	$(237,070)	
7	$ (180,000)	$ (52,900)	$ (164,324)	$ (72,306)	$(236,630)	
8	$ -	$ (60,835)	$ (149,955)	$ (71,303)	$(221,258)	
9	$ -	$ (69,960)	$ (138,912)	$ (71,204)	$(210,116)	
10	$ (216,000)	$ (80,454)	$ (130,196)	$ (85,337)	$(215,534)	
11	$ -	$ (92,522)	$ (123,171)	$ (85,725)	$(208,896)	
12	$ -	$(106,401)	$ (117,411)	$ (86,692)	$(204,103)	
13	$ -	$(122,361)	$ (112,623)	$ (88,147)	$(200,769)	ESL

Year	Operating hours	Cumulative hours	
1	500	500	
2	1500	2000	
3	2000	4000	
4	2000	6000	Rebuild
5	2000	8000	
6	2000	10000	
7	2000	12000	Rebuild
8	2000	14000	
9	2000	16000	
10	2000	18000	Rebuild
11	2000	20000	
12	2000	22000	
13	2000	24000	Replace

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.

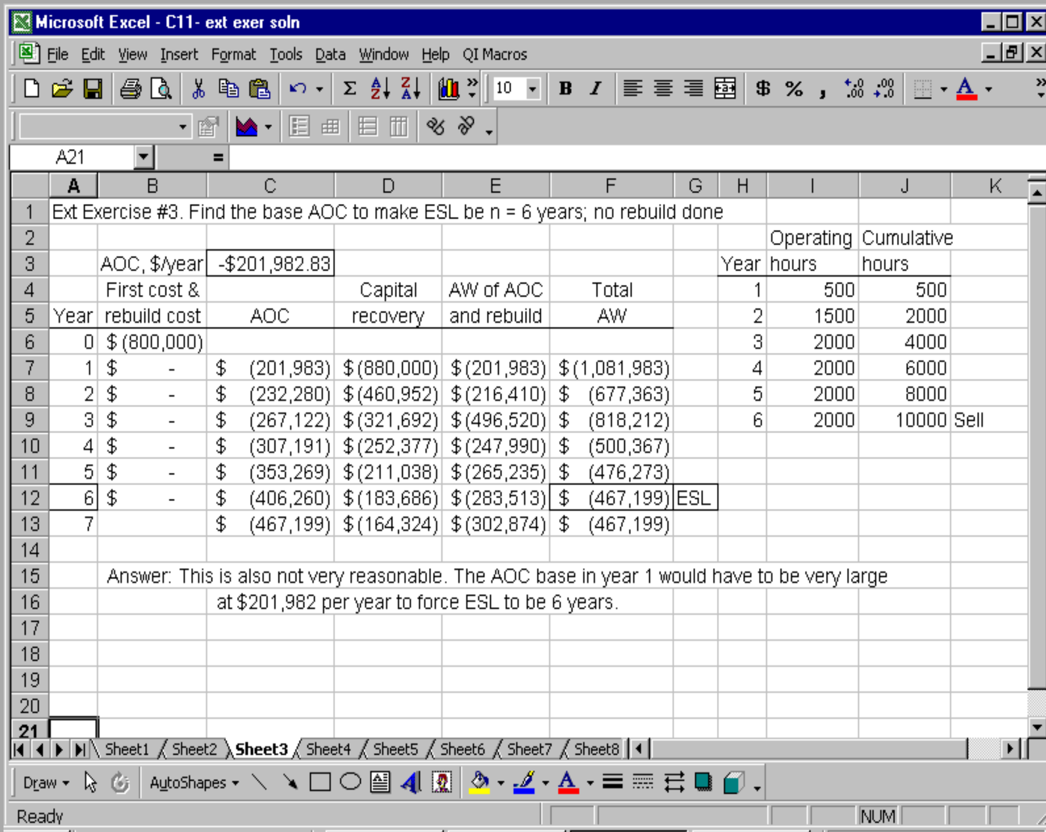
Ext Exercise Solution #2. Find required market value at end of year 6 to make ESL be n = 6 years

Year	First cost & rebuild cost	AOC	Capital recovery	AW of AOC and rebuild	Total AW	
0	$ (800,000)					
1	$ -	$ (25,000)	$ (880,000)	$ (25,000)	$ (905,000)	
2	$ -	$ (25,000)	$ (460,952)	$ (25,000)	$ (485,952)	
3	$ -	$ (25,000)	$ (321,692)	$ (25,000)	$ (346,692)	
4	$ (150,000)	$ (25,000)	$ (252,377)	$ (57,321)	$ (309,697)	
5	$ -	$ (40,000)	$ (211,038)	$ (54,484)	$ (265,522)	
6	$ 1,420,983	$ (46,000)	$ (183,686)	$ 130,786	$ (52,900)	ESL
7	$ -	$ (52,900)	$ (164,324)	$ 111,424	$ (52,900)	
8	$ -	$ (60,835)	$ (149,955)	$ 96,361	$ (53,594)	
9	$ -	$ (69,960)	$ (138,912)	$ 84,113	$ (54,799)	
10	$ -	$ (80,454)	$ (130,196)	$ 73,787	$ (56,409)	
11	$ -	$ (92,522)	$ (123,171)	$ 64,813	$ (58,358)	
12	$ -	$ (106,401)	$ (117,411)	$ 56,806	$ (60,604)	
13	$ -	$ (122,361)	$ (112,623)	$ 49,500	$ (63,123)	

Year	Operating hours	Cumulative hours	
1	500	500	
2	1500	2000	
3	2000	4000	
4	2000	6000	Rebuild
5	2000	8000	
6	2000	10000	
7	2000	12000	Rebuild
8	2000	14000	
9	2000	16000	
10	2000	18000	Rebuild
11	2000	20000	
12	2000	22000	
13	2000	24000	Replace

Answer: The market value would be extremely high at $1.42 million to make ESL be 6 years.
This is substantially more than the pump cost new at $800,000.
SOLVER was used.

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. Also 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	Ext Exercise #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.								

Neither suggestion in #2 or #3 are good options.

Case Study Solution

1. **<u>Plan 1 – Current system augmented with conveyor</u>**

$$AW_{current} = -15{,}000(A/P,12\%,7) + 5000(A/F,12\%,7) – 180{,}000(2.4)(0.01)$$
$$= -15{,}000(0.21912) + 5000(0.09912) – 4320$$
$$- \$-7111$$

$$AW_{new} = -70{,}000(A/P,12\%,10) + 8000(A/F,12\%,10) – 240{,}000(2.4)(0.01)$$
$$= -70{,}000(0.17698) + 8000(0.05698) – 5760$$
$$= \$-17{,}693$$

Plan 1 AW = $AW_{current} + AW_{new}$
= \$-24,804

Plan 2 – Conveyor plus old mover

$AW_{conveyor}$ = -115,000(A/P,12%,15) – 400,000(0.0075)
= -115,000(0.14682) - 3000
= \$-19,884

AW_{old} = -15,000(A/P,12%,7) + 5000(A/F,12%,7) – 400,000(0.75)(0.01)
= -15,000(0.21912) + 5000(0.09912) – 3000
= \$-5791

Plan 2 AW = $AW_{conveyor} + AW_{old}$
= \$-25,675

Plan 2 – Conveyor plus new mover

$AW_{conveyor}$ = \$-19,884

AW_{new} = -40,000(A/P,12%,12) + 3500(A/F,12%,12) – 400,000(0.75)(0.01)
= -40,000(0.16144) + 3500(0.04144) – 3000
= \$-9312

Plan 3 AW = $AW_{conveyor} + AW_{new}$
= \$-29,196

Conclusion: Select plan 1 (Current system augmented with conveyor) at \$-24,804.

2. $AW_{contractor}$ = -21,000 –380,000(0.01)
= \$-24,800

The AW is just about identical to plan 1 (\$-24,804), so the decision is up to thre management of the company.

Chapter 12

Selection from Independent Projects Under Budget Limitation

Solutions to Problems

12.1 The paragraph should mention: independent projects versus mutually exclusive alternatives; limit placed on total capital invested using the sum of initial investment amounts; selection of a project in its entirely or to not select it (do-nothing); and to maximize the return using some measure such as PW of net cash flows at the MARR.

12.2 Any net positive cash flows that occur in any project are reinvested at the MARR from the time they are realized until the end of the longest-lived project being evaluated. (This is similar to the assumption made in Section 7.5 when the composite rate of return is determined, but here the only rate involved is the MARR.) In effect, this makes the lives equal for all projects, a requirement to correctly apply the PW method.

12.3 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

12.4 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

12.5 (a) Develop the bundles with less than $325,000 investment, and select the one with the largest PW value.

Bundle	Projects	Initial investment, $	NCF, $/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	-11,938
5	E	-200,000	82,000	237,464
6	AB	-225,000	74,000	169,784
7	AC	-220,000	125,000	446,864
8	AD	-320,000	89,000	154,807
9	AE	-300,000	132,000	404,208
10	BC	-245,000	99,000	283,156
11	BE	-325,000	106,000	240,500
12	CE	-320,000	157,000	517,580
13	DN	0	0	0

$$PW_1 = -100{,}000 + 50{,}000(P/A,10\%,8)$$
$$= -100{,}000 + 50{,}000(5.3349)$$
$$= \$166{,}746$$

$$PW_2 = -125{,}000 + 24{,}000(P/A,10\%,8)$$
$$= -125{,}000 + 24{,}000(5.3349)$$
$$= \$3038$$

$$PW_3 = -120{,}000 + 75{,}000(P/A,10\%,8)$$
$$= -120{,}000 + 75{,}000(5.3349)$$
$$= \$280{,}118$$

$$PW_4 = -220{,}000 + 39{,}000(P/A,10\%,8)$$
$$= -220{,}000 + 39{,}000(5.3349)$$
$$= \$-11{,}939$$

$$PW_5 = -200{,}000 + 82{,}000(P/A,10\%,8)$$
$$= -200{,}000 + 82{,}000(5.3349)$$
$$= \$237{,}462$$

All other PW values are obtained by adding the respective PW for bundles 1 through 5.

Conclusion: Select PW = $517,580, which is bundle 12 (projects C and E) with $320,000 total investment.

(b) For mutually exclusive alternatives, select the single project with the largest PW. This is C with PW = $280,118.

12.6 Determine PW at 10% for each single project (row 14). Determine the feasible bundles (from Problem 12.5) and add the respective PW values (column H). Select the largest PW value, which is for the bundle containing projects C and E.

Microsoft Excel — Prob 12.6

G15 = CE

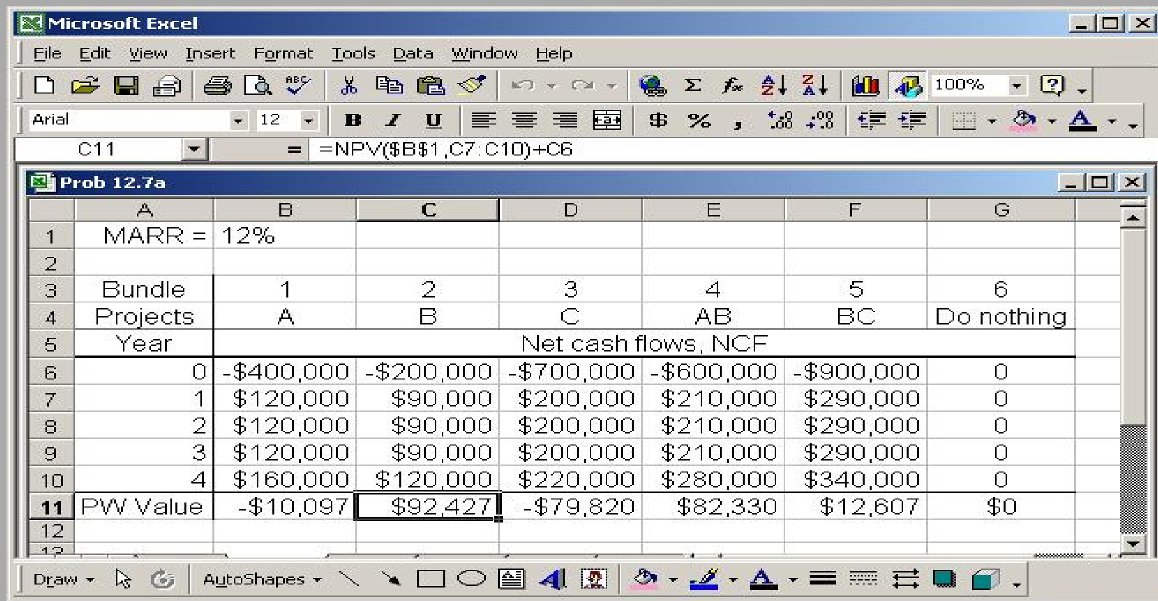
	A	B	C	D	E	F	G	H
1								
2		Net cash flows, $ per year					ME evaluation	
3	Year	A	B	C	D	E	Bundle	PW(bundle)
4	0	-100000	-125000	-120000	-220000	-200000	A	$ 166,746
5	1	50000	24000	75000	39000	82000	B	$ 3,038
6	2	50000	24000	75000	39000	82000	C	$ 280,119
7	3	50000	24000	75000	39000	82000	D	$ (11,938)
8	4	50000	24000	75000	39000	82000	E	$ 237,464
9	5	50000	24000	75000	39000	82000	AB	$ 169,785
10	6	50000	24000	75000	39000	82000	AC	$ 446,866
11	7	50000	24000	75000	39000	82000	AD	$ 154,808
12	8	50000	24000	75000	39000	82000	AE	$ 404,210
13							BC	$ 283,158
14	PW @ 10%	$166,746	$ 3,038	$280,119	$(11,938)	$237,464	BE	$ 240,502
15							CE	$ 517,583
16							DN	0
17								
18	Select:	$517,583						
19								
20								
21								

=MAX(H4:H16)

=NPV(10%,F$5:F$12)+ F$4

=D14+F14

12.7 (a) PW analysis of the 6 viable bundles is shown below. NPV functions are used to find PW values. Select project B for a total of $200,000, since it is the only one of the three single projects with PW > 0 at MARR = 12% per year.

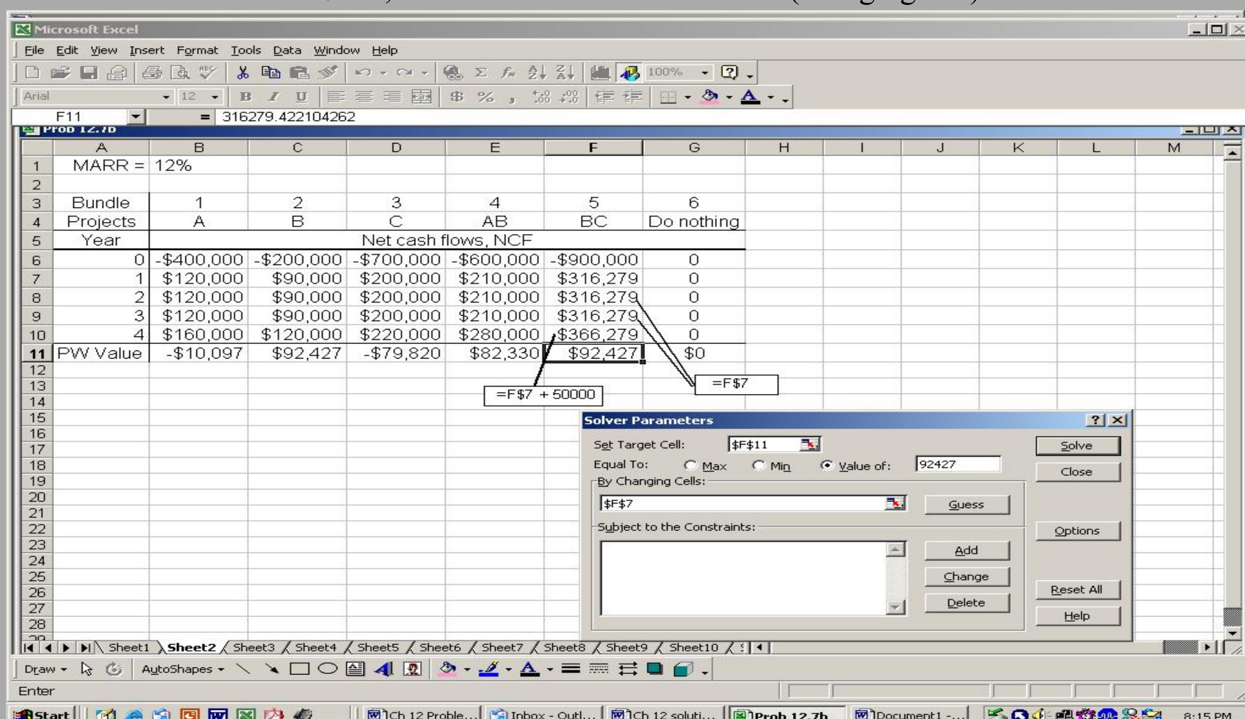


C11 = =NPV($B$1,C7:C10)+C6

Prob 12.7a

	A	B	C	D	E	F	G
1	MARR =	12%					
2							
3	Bundle	1	2	3	4	5	6
4	Projects	A	B	C	AB	BC	Do nothing
5	Year	Net cash flows, NCF					
6	0	-$400,000	-$200,000	-$700,000	-$600,000	-$900,000	0
7	1	$120,000	$90,000	$200,000	$210,000	$290,000	0
8	2	$120,000	$90,000	$200,000	$210,000	$290,000	0
9	3	$120,000	$90,000	$200,000	$210,000	$290,000	0
10	4	$160,000	$120,000	$220,000	$280,000	$340,000	0
11	PW Value	-$10,097	$92,427	-$79,820	$82,330	$12,607	$0

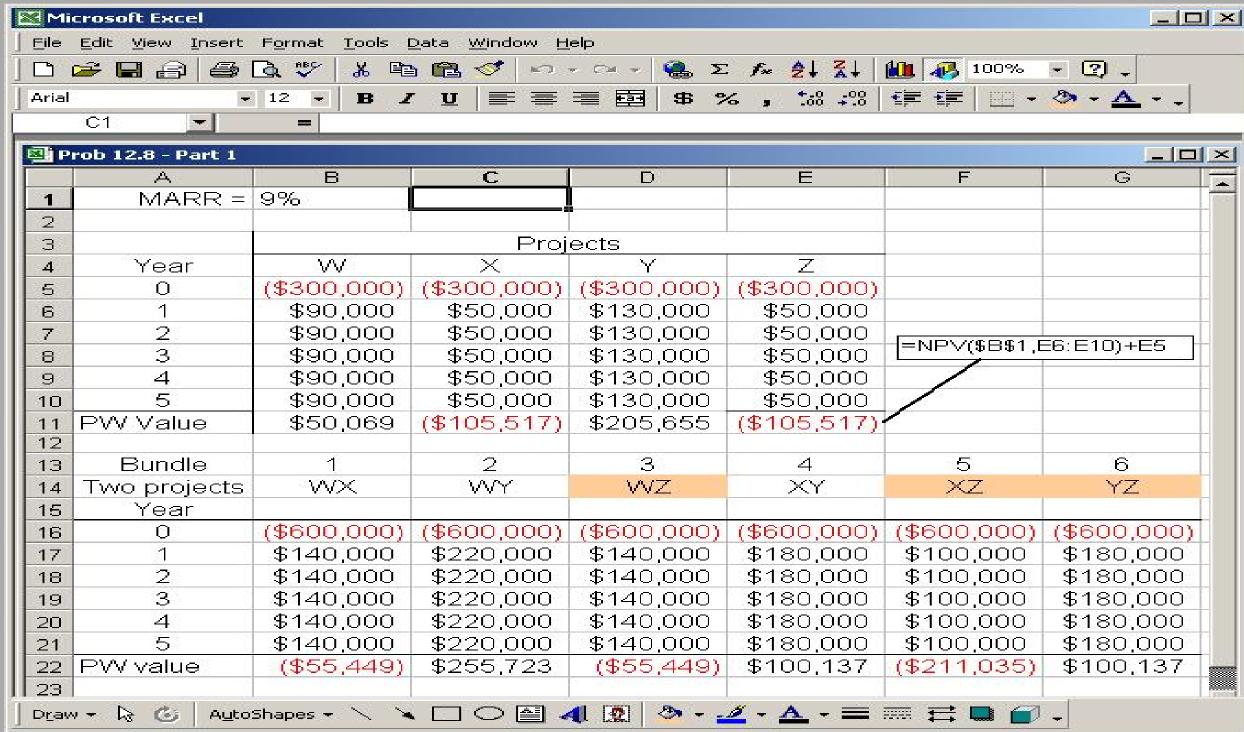
(b) Change the NCF for bundle 5 (B and C) such that the PW is equal to PW_2 = $92,427. Use SOLVER with cell F11 as the target cell to find the necessary minimum NCF for both B and C of $316,279 as shown below in cell F7 (changing cell).



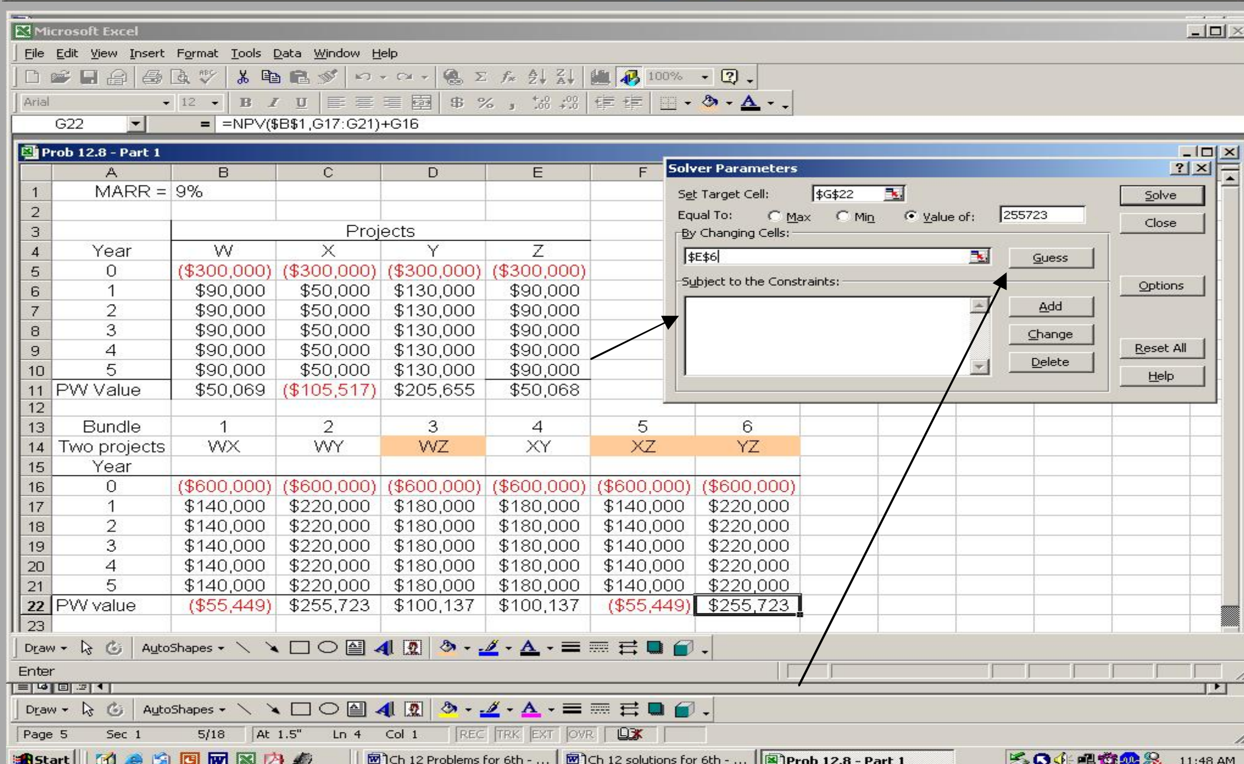
F11 = 316279.422104262

	A	B	C	D	E	F	G
1	MARR =	12%					
2							
3	Bundle	1	2	3	4	5	6
4	Projects	A	B	C	AB	BC	Do nothing
5	Year	Net cash flows, NCF					
6	0	-$400,000	-$200,000	-$700,000	-$600,000	-$900,000	0
7	1	$120,000	$90,000	$200,000	$210,000	$316,279	0
8	2	$120,000	$90,000	$200,000	$210,000	$316,279	0
9	3	$120,000	$90,000	$200,000	$210,000	$316,279	0
10	4	$160,000	$120,000	$220,000	$280,000	$366,279	0
11	PW Value	-$10,097	$92,427	-$79,820	$82,330	$92,427	$0

12.8 (Solution description on next page.)



	A	B	C	D	E	F	G
1	MARR =	9%					
2							
3			Projects				
4	Year	W	X	Y	Z		
5	0	($300,000)	($300,000)	($300,000)	($300,000)		
6	1	$90,000	$50,000	$130,000	$50,000		
7	2	$90,000	$50,000	$130,000	$50,000		
8	3	$90,000	$50,000	$130,000	$50,000		
9	4	$90,000	$50,000	$130,000	$50,000		
10	5	$90,000	$50,000	$130,000	$50,000		
11	PW Value	$50,069	($105,517)	$205,655	($105,517)		
12							
13	Bundle	1	2	3	4	5	6
14	Two projects	WX	WY	WZ	XY	XZ	YZ
15	Year						
16	0	($600,000)	($600,000)	($600,000)	($600,000)	($600,000)	($600,000)
17	1	$140,000	$220,000	$140,000	$180,000	$100,000	$180,000
18	2	$140,000	$220,000	$140,000	$180,000	$100,000	$180,000
19	3	$140,000	$220,000	$140,000	$180,000	$100,000	$180,000
20	4	$140,000	$220,000	$140,000	$180,000	$100,000	$180,000
21	5	$140,000	$220,000	$140,000	$180,000	$100,000	$180,000
22	PW value	($55,449)	$255,723	($55,449)	$100,137	($211,035)	$100,137



	A	B	C	D	E	F	G
1	MARR =	9%					
2							
3			Projects				
4	Year	W	X	Y	Z		
5	0	($300,000)	($300,000)	($300,000)	($300,000)		
6	1	$90,000	$50,000	$130,000	$90,000		
7	2	$90,000	$50,000	$130,000	$90,000		
8	3	$90,000	$50,000	$130,000	$90,000		
9	4	$90,000	$50,000	$130,000	$90,000		
10	5	$90,000	$50,000	$130,000	$90,000		
11	PW Value	$50,069	($105,517)	$205,655	$50,068		
12							
13	Bundle	1	2	3	4	5	6
14	Two projects	WX	WY	WZ	XY	XZ	YZ
15	Year						
16	0	($600,000)	($600,000)	($600,000)	($600,000)	($600,000)	($600,000)
17	1	$140,000	$220,000	$180,000	$180,000	$140,000	$220,000
18	2	$140,000	$220,000	$180,000	$180,000	$140,000	$220,000
19	3	$140,000	$220,000	$180,000	$180,000	$140,000	$220,000
20	4	$140,000	$220,000	$180,000	$180,000	$140,000	$220,000
21	5	$140,000	$220,000	$180,000	$180,000	$140,000	$220,000
22	PW value	($55,449)	$255,723	$100,137	$100,137	($55,449)	$255,723

12.8 (cont.) There are 6 2-project bundles. First spreadsheet shows cash flows and PW values at 9% for single projects and bundles. If the NCF for Z is \$50,000, Projects WY are selected with PW_2 = \$255,723. Minimum NCF for project Z must make PW for either bundle WZ, XZ, or YZ have a PW of at least that of projects WY. Use SOLVER (second spreadsheet) to find

Min NCF for Z = \$90,000

to obtain min PW_6 = \$255,723 for projects YZ. This is the minimum NCF for Z to be selected as part of the twosome.

If Solver is applied 2 more times the minimum NCF for the other bundles are as follows:

Projects	Min NCF for Z
XZ	\$170,000
WZ	130,000

12.9 b = \$800,000 i = 10% n_j = 4 years 6 viable bundles

Bundle	Projects	NCF_{j0}	NCF_{jt}	S	PW at 10%
1	A	\$-250,000	\$ 50,000	\$ 45,000	\$-60,770
2	B	-300,000	90,000	-10,000	-21,539
3	C	-550,000	150,000	100,000	- 6,215
4	AB	-550,000	140,000	35,000	-82,309*
5	AC	-800,000	200,000	145,000	-66,985*
6	Do nothing	0	0	0	0

$PW_j = NCF_j(P/A,10\%,4) + S(P/F,10\%,4) - NCF_{j0}$

*Add single-project PW values for j = 4 and 5. Since PW < 0 for A, B and C, by inspection, bundles 4 and 5 will have PW < 0. There is no need to determine their PW values. Since no PW > 0,

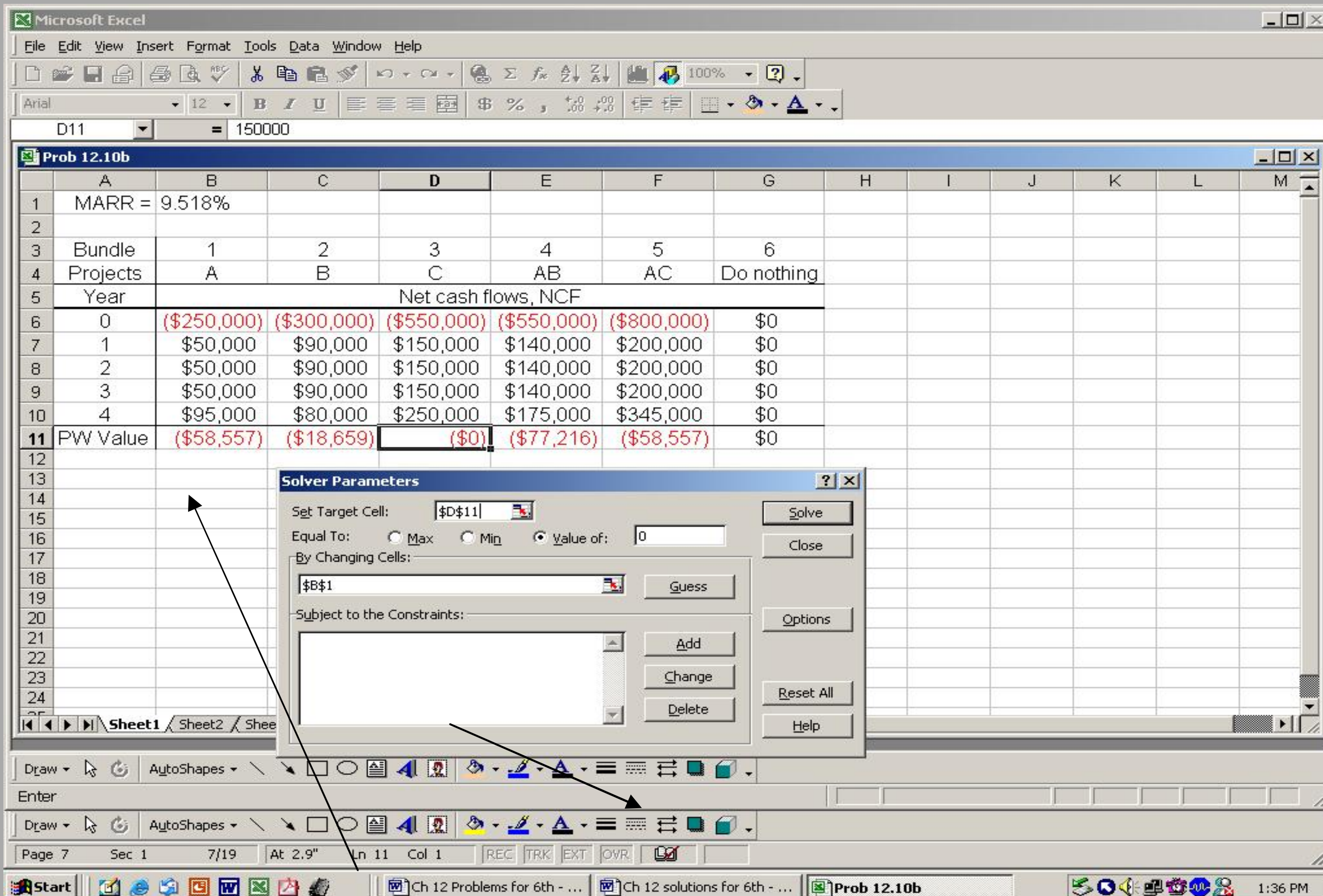
Select DO NOTHING project.

12.10 Set up spreadsheet and determine that the Do Nothing bundle is the only acceptable one with PW = \$-6219.

(a) Since the initial investment occurs at time t = 0, maximum initial investment for C at which PW = 0 is

$$-550,000 + (-6219) = \$-543,781$$

(b) Use SOLVER with the target cell as D11 for PW = 0. Result is MARR = 9.518% in cell B1.



	A	B	C	D	E	F	G
1	MARR =	9.518%					
2							
3	Bundle	1	2	3	4	5	6
4	Projects	A	B	C	AB	AC	Do nothing
5	Year	Net cash flows, NCF					
6	0	($250,000)	($300,000)	($550,000)	($550,000)	($800,000)	$0
7	1	$50,000	$90,000	$150,000	$140,000	$200,000	$0
8	2	$50,000	$90,000	$150,000	$140,000	$200,000	$0
9	3	$50,000	$90,000	$150,000	$140,000	$200,000	$0
10	4	$95,000	$80,000	$250,000	$175,000	$345,000	$0
11	PW Value	($58,557)	($18,659)	($0)	($77,216)	($58,557)	$0

12.11 (a) There are $2^8 = 256$ separate bundles possible. Only 1, 2 or 3 projects can be accepted. With b = $400,000 and selection restrictions, there are only 4 viable bundles.

Bundle	Projects	Initial investment, $	PW at 10%, $
1	2	-300,000	35,000
2	5	-195,000	125,000
3	8	-400,000	110,000
4	2,7	-400,000	97,000

Select project 5 with PW = $125,000 and $195,000 invested. This assumes the remaining $205,000 is invested at the MARR of 10% per year in other investment opportunities.

(b) The second best choice is project 8 with PW = $110,000. This is a good choice, since it invests the entire $400,000 at a rate of return in excess of the 10% MARR since PW is significantly above zero.

12.12 (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 = $60,000, 11 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	SH	-55,000	23,890
10	AM	-35,000	15,325
11	AE	-50,000	12,335
12	ME	-35,000	3,010
13	MH	-50,000	18,350
14	SAM	-50,000	23,865
15	SME	-50,000	11,550
16	AME	-60,000	15,335

Select projects S and H with PW = $23,890 and $55,000 invested.
(A close second are projects S, A and M with PW = $23,865 and $50,000 invested.)

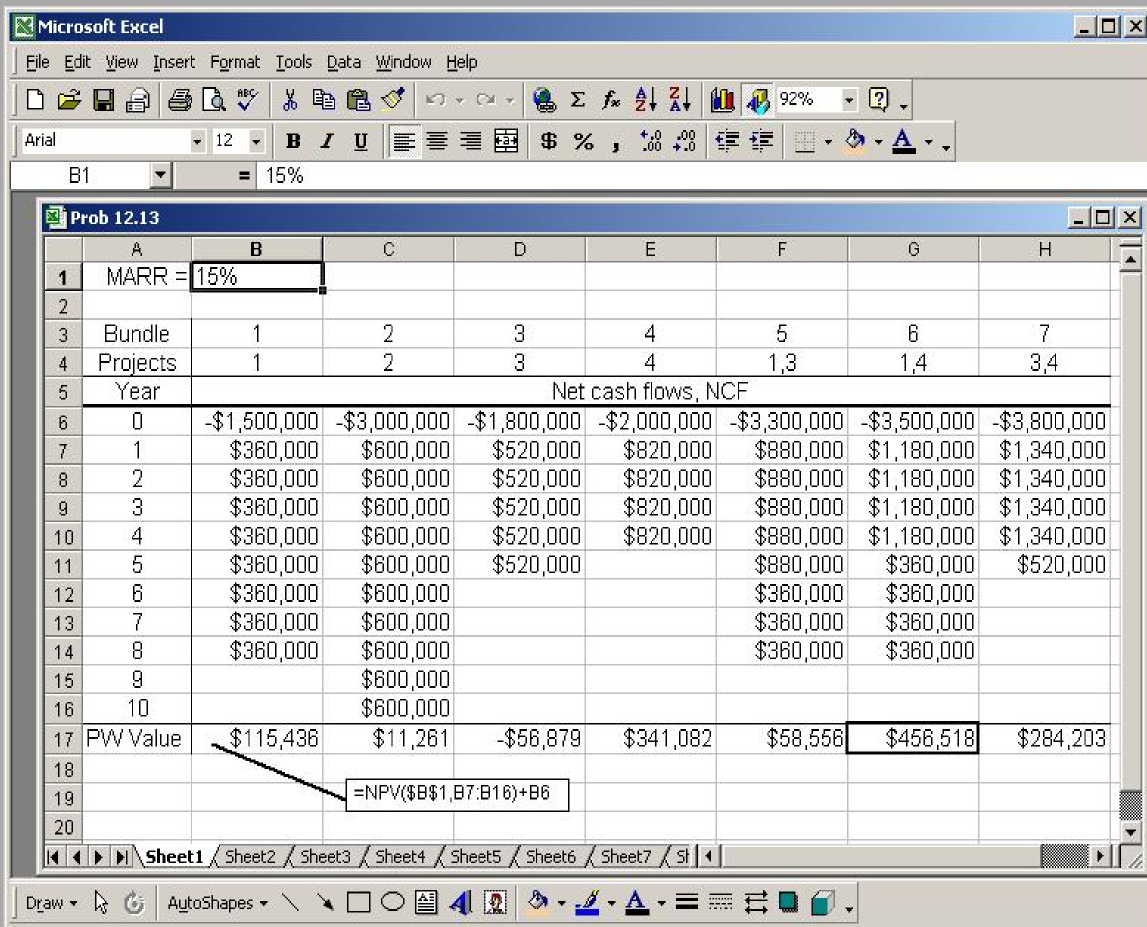
(c) Select all projects since they each have PW > 0 at 12%.

12.13 (a) The bundles and PW values are determined at MARR = 15% per year.

Bundle	Projects	Initial investment, $	NCF, $ per year	Life, years	PW at 15%
1	1	-1.5 mil	360,000	8	$115,428
2	2	-3.0	600,000	10	11,280
3	3	-1.8	520,000	5	- 56,856
4	4	-2.0	820,000	4	341,100
5	1,3	-3.3	880,000	1-5	58,572
			360,000	6-8	
6	1,4	-3.5	1,180,000	1-4	456,528
			360,000	5-8	
7	3,4	-3.8	1,340,000	1-4	284,244
			520,000	5	

Select PW = $456,528 for projects 1 and 4 with $3.5 million invested.

12.13 (cont) (b) Set up a spreadsheet for all 7 bundles. Select projects 1 and 4 with the largest PW = $456,518 and invest $3.5 million.



	A	B	C	D	E	F	G	H
1	MARR =	15%						
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						
6	0	-$1,500,000	-$3,000,000	-$1,800,000	-$2,000,000	-$3,300,000	-$3,500,000	-$3,800,000
7	1	$360,000	$600,000	$520,000	$820,000	$880,000	$1,180,000	$1,340,000
8	2	$360,000	$600,000	$520,000	$820,000	$880,000	$1,180,000	$1,340,000
9	3	$360,000	$600,000	$520,000	$820,000	$880,000	$1,180,000	$1,340,000
10	4	$360,000	$600,000	$520,000	$820,000	$880,000	$1,180,000	$1,340,000
11	5	$360,000	$600,000	$520,000		$880,000	$360,000	$520,000
12	6	$360,000	$600,000			$360,000	$360,000	
13	7	$360,000	$600,000			$360,000	$360,000	
14	8	$360,000	$600,000			$360,000	$360,000	
15	9		$600,000					
16	10		$600,000					
17	PW Value	$115,436	$11,261	-$56,879	$341,082	$58,556	$456,518	$284,203

=NPV($B$1,B7:B16)+B6

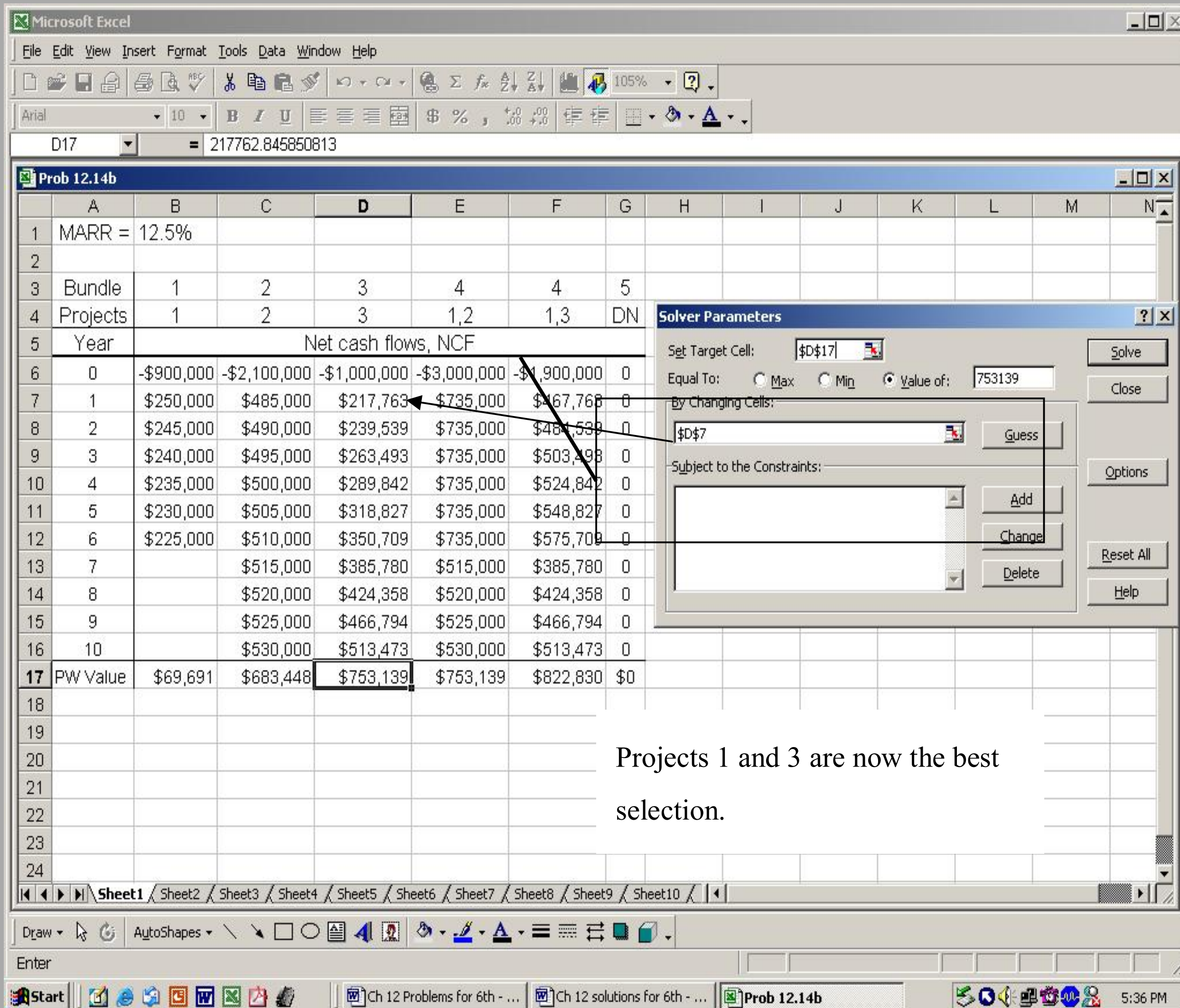
12.14 (a) Spreadsheet shows the solution. Select projects 1 and 2 for a budget of $3.0 million and PW = $753,139.

E17 = =NPV($B$1,E7:E16)+E6

Prob 12.14a

	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	$220,000	$735,000	$465,000	0
9	3	$240,000	$495,000	$242,000	$735,000	$482,000	0
10	4	$235,000	$500,000	$266,200	$735,000	$501,200	0
11	5	$230,000	$505,000	$292,820	$735,000	$522,820	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	-$149,749	$753,139	-$80,058	$0
18							

12.14 (cont) (b) Use SOLVER with the target cell D17 to equal $753,139. Result is a required year one NCF for project 3 of $217,763 (cell D7). However, with this increased NCF and life for project 3, the best selection is now projects 1 and 3 with PW = $822,830 (cell F17).



	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	$217,763	$735,000	$467,763	0
8	2	$245,000	$490,000	$239,539	$735,000	$484,539	0
9	3	$240,000	$495,000	$263,493	$735,000	$503,493	0
10	4	$235,000	$500,000	$289,842	$735,000	$524,842	0
11	5	$230,000	$505,000	$318,827	$735,000	$548,827	0
12	6	$225,000	$510,000	$350,709	$735,000	$575,709	0
13	7		$515,000	$385,780	$515,000	$385,780	0
14	8		$520,000	$424,358	$520,000	$424,358	0
15	9		$525,000	$466,794	$525,000	$466,794	0
16	10		$530,000	$513,473	$530,000	$513,473	0
17	PW Value	$69,691	$683,448	$753,139	$753,139	$822,830	$0

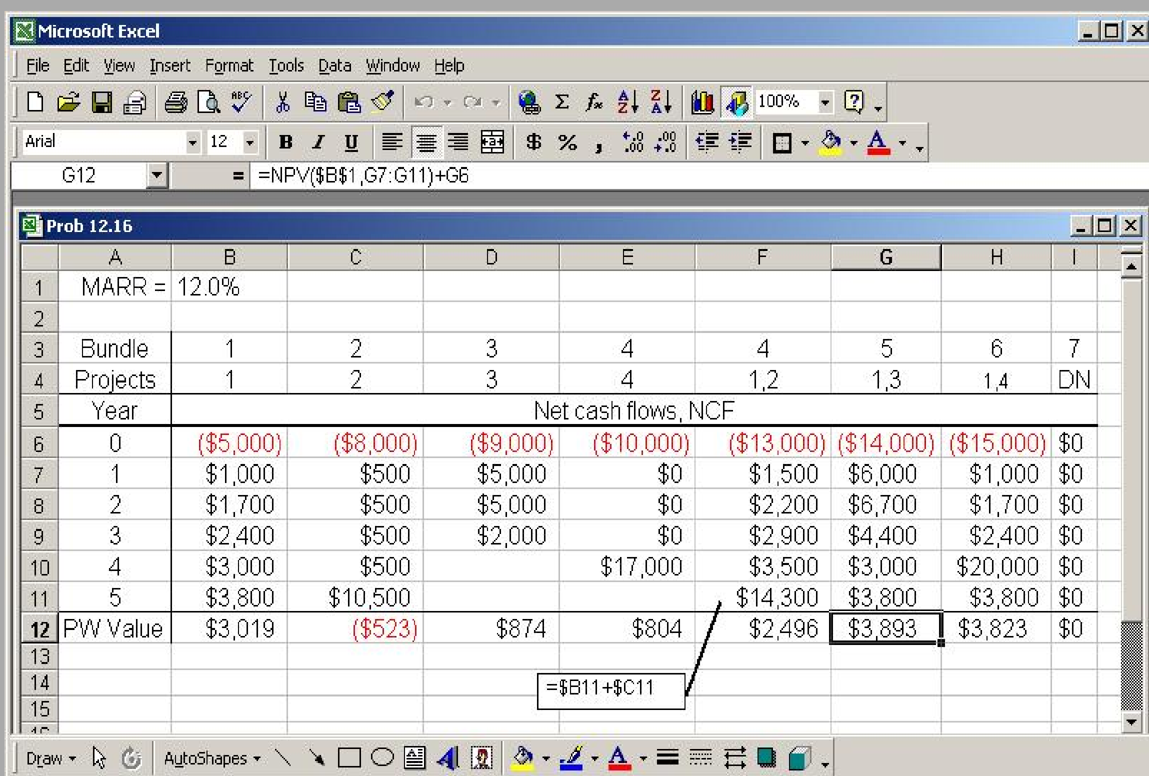
Projects 1 and 3 are now the best selection.

12.15 Budget limit, b = $16,000 MARR = 12% per year

Bundle	Projects	Investment	NCF for years 1 through 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

Since PW_6 = $3893 is largest, select bundle 6, which is projects 1 and 3.

12.16 Spreadsheet solution for Problem 12.15. 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							
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

12.17 For the bundle comprised of projects 3 and 4, the net cash flows are:

Year	0	1	2	3	4	5
NCF	$-19,000	5000	5000	2000	17,000	0

Use Equation [12.2] to compute the PW value at 12%. The longest-lived of the four is project 2 with $n_L = 5$ years.

$$PW = -19{,}000 + [5{,}000(F/A,12\%,2)(F/P,12\%,3) + 2{,}000(F/P,12\%,2) + 17{,}000(F/P,12\%,1)](P/F,12\%,5)$$

$$= -19{,}000 + [5{,}000(2.12)(1.4049) + 2{,}000(1.2544) + 17{,}000(1.12)](0.5674)$$
$$= \$1676$$

The PW value using the NCF values directly is

$$PW = -19{,}000 + 5000(P/A,12\%,2) + 2000(P/F,12\%,3) + 17{,}000(P/F,12\%,4)$$
$$= -19{,}000 + 5000(1.6901) + 2000(0.7118) + 17{,}000(0.6355)$$
$$= \$1677$$

The PW values are the same (allowing for round-off error).

12.18 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.

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

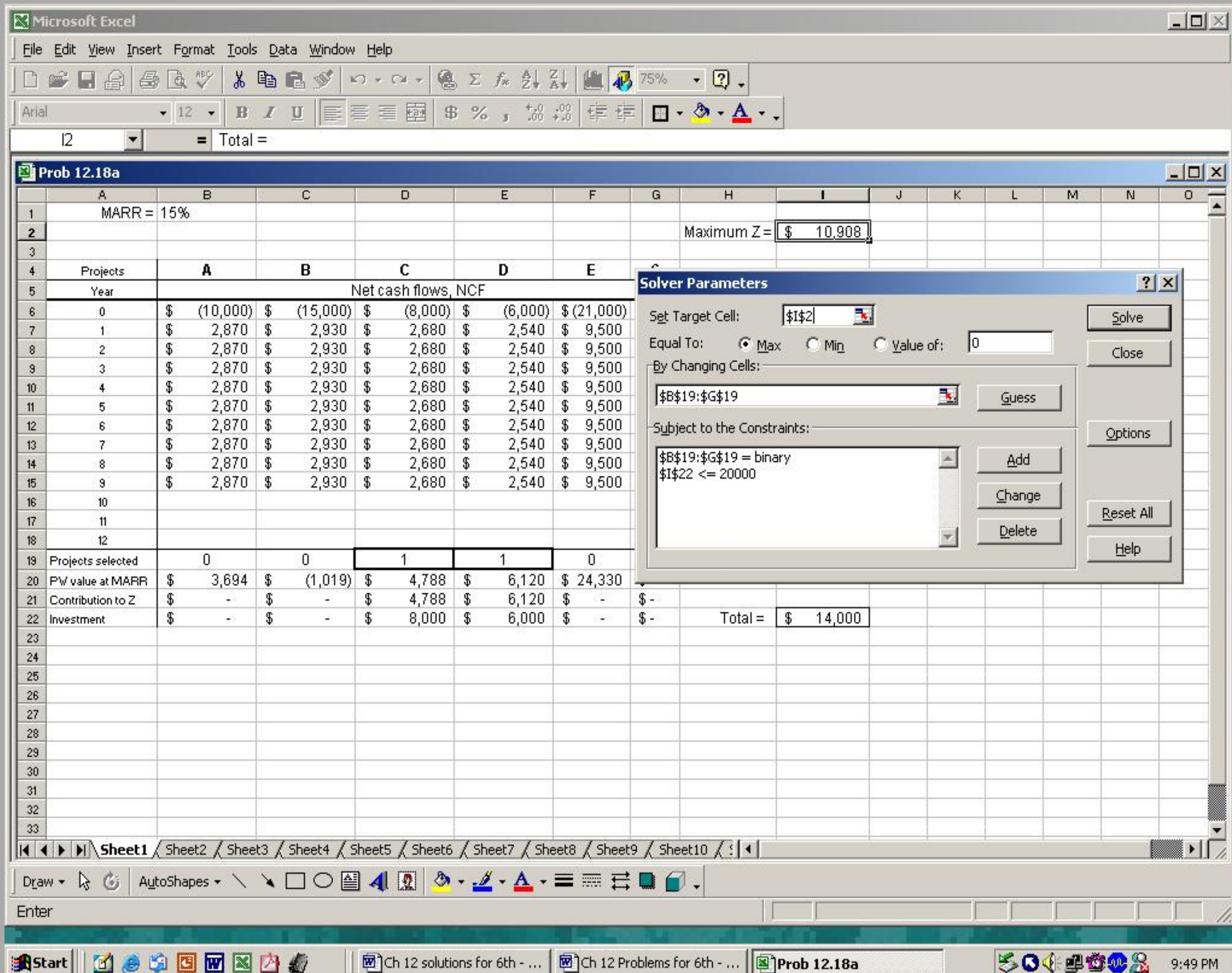
The linear programming formulation is:

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

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

$x_k = 0$ or 1 for $k = 1$ to 5

(a) For b = $20,000: The spreadsheet solution uses the general 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 (cell I22) 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					
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	$ -	$ -	$ 4,788	$ 6,120	$ -	$ -		
22	Investment	$ -	$ -	$ 8,000	$ 6,000	$ -	$ -	Total =	$ 14,000

(b) b = \$13,000: Again, all amounts are in \$1000 units. Simply change 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.

12.19 (a) Use the capital budgeting template with MARR = 10% and a budget constraint of \$325,000. The solution is to select projects C and E (row 19) with \$320,000 invested and a maximized PW = \$517,583 (cell I5).

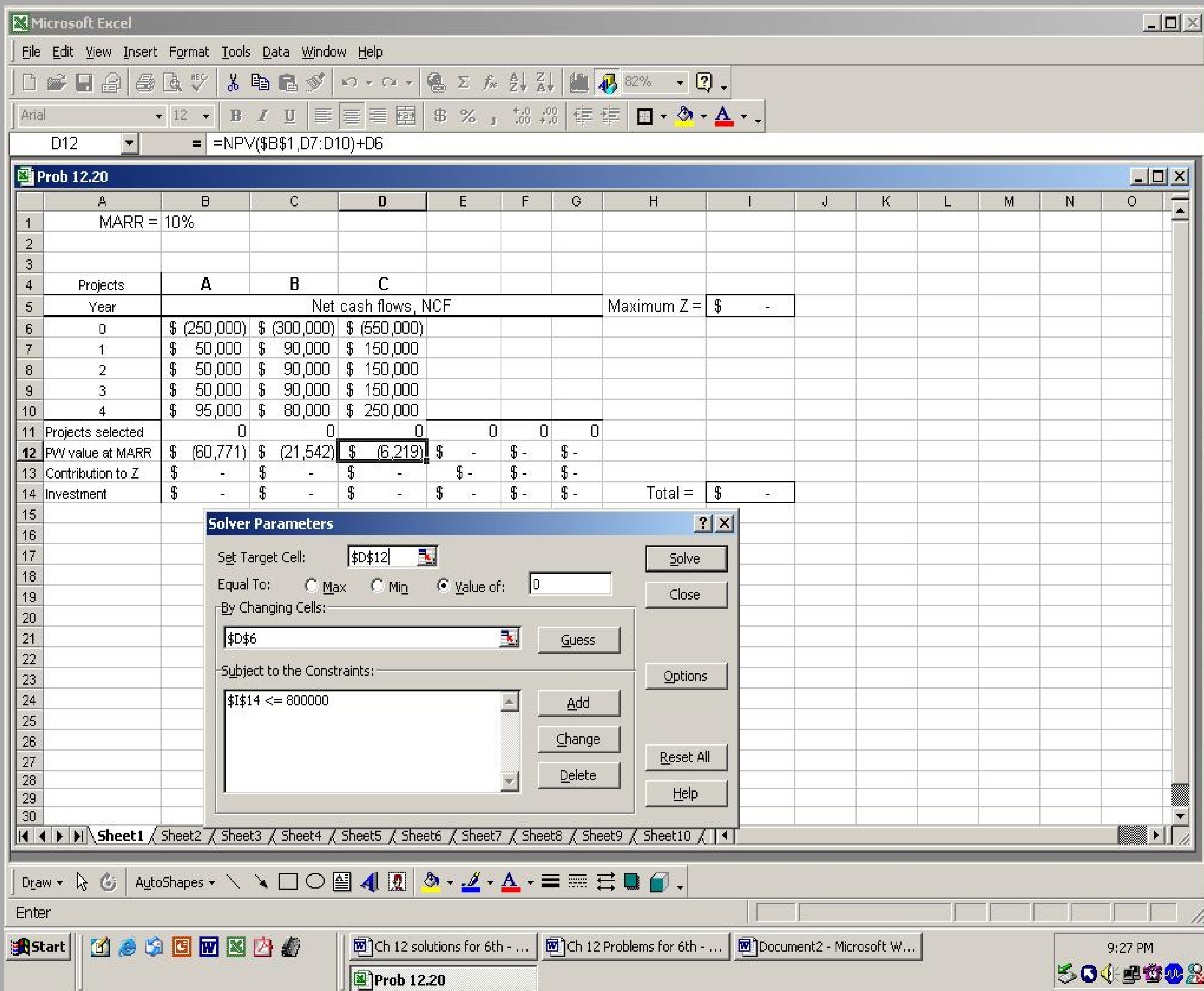
Microsoft Excel — Prob 12.19

	A	B	C	D	E	F	G	H	I
1	MARR =	10%							
2									
3									
4	Projects	A	B	C	D	E			
5	Year	Net cash flows, NCF						Maximum Z =	$517,583
6	0	$ (100,000)	$ (125,000)	$ (120,000)	$ (220,000)	$ (200,000)			
7	1	$ 50,000	$ 24,000	$ 75,000	$ 39,000	$ 82,000			
8	2	$ 50,000	$ 24,000	$ 75,000	$ 39,000	$ 82,000			
9	3	$ 50,000	$ 24,000	$ 75,000	$ 39,000	$ 82,000			
10	4	$ 50,000	$ 24,000	$ 75,000	$ 39,000	$ 82,000			
11	5	$ 50,000	$ 24,000	$ 75,000	$ 39,000	$ 82,000			
12	6	$ 50,000	$ 24,000	$ 75,000	$ 39,000	$ 82,000			
13	7	$ 50,000	$ 24,000	$ 75,000	$ 39,000	$ 82,000			
14	8	$ 50,000	$ 24,000	$ 75,000	$ 39,000	$ 82,000			
15	9								
16	10								
17	11								
18	12								
19	Projects selected	0	0	1	0	1	0		
20	PW value at MARR	$ 166,746	$ 3,038	$ 280,119	$ (11,938)	$ 237,464	$ -		
21	Contribution to Z	$ -	$ -	$ 280,119	$ -	$ 237,464	$ -		
22	Investment	$ -	$ -	$ 120,000	$ -	$ 200,000	$ -	Total =	$320,000

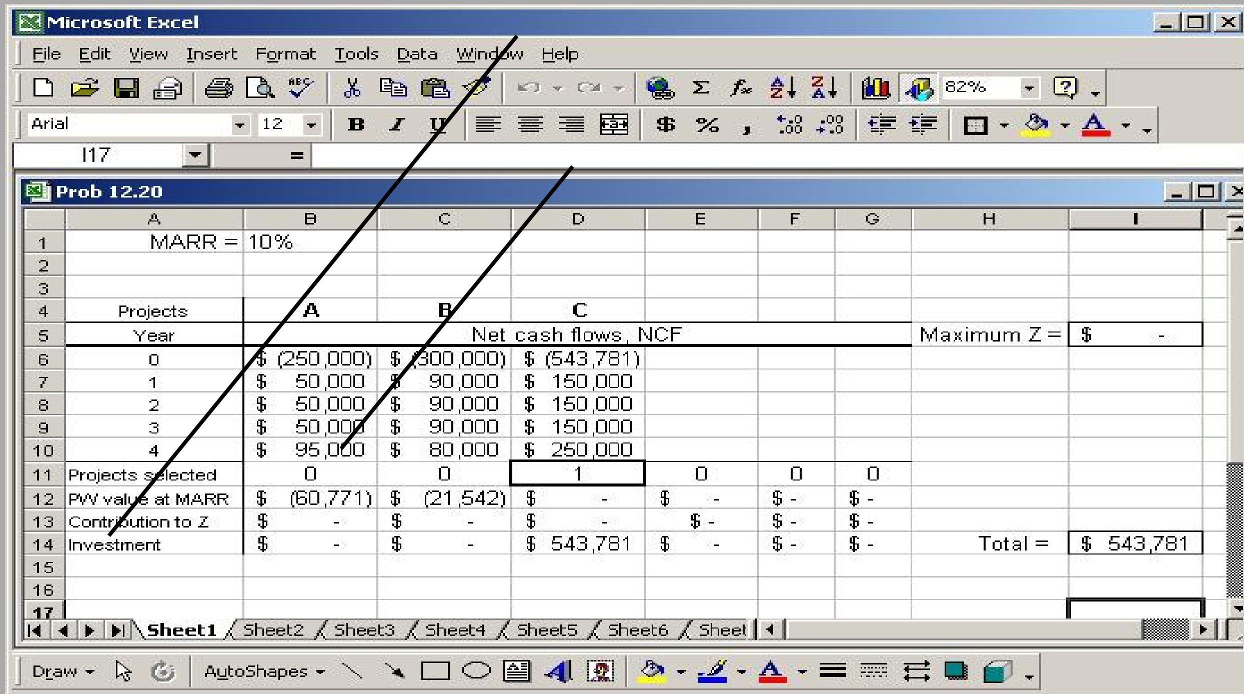
(b) Change cell B1 to 12% and the budget constraint to $500,000. Solution is

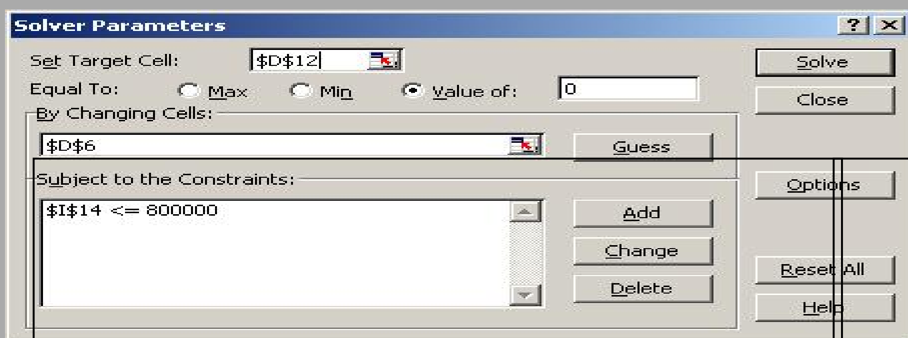
Select projects A, C and E for Z = $608,301 and a total of $420,000 invested.

12.20 The capital budgeting solution with MARR = 10% and b = $800,000 is to Do Nothing since all three projects have PW < 0.

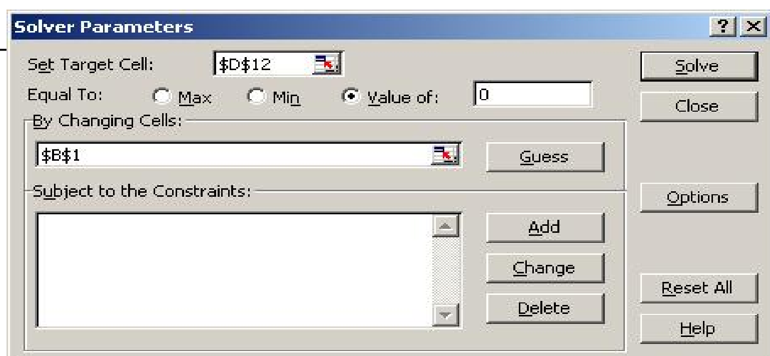


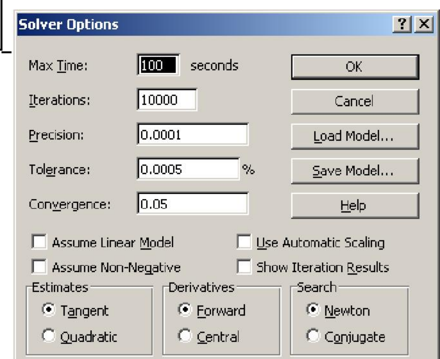
12.20 (cont) (a) To determine that the maximum investment in C is $543,781 using SOLVER, set up the solution with '1' in cell D11 to select project C only, target cell as D12 with a value of $0, changing cell as D6 and delete the binary constraint. Spreadsheet and SOLVER template are shown below.



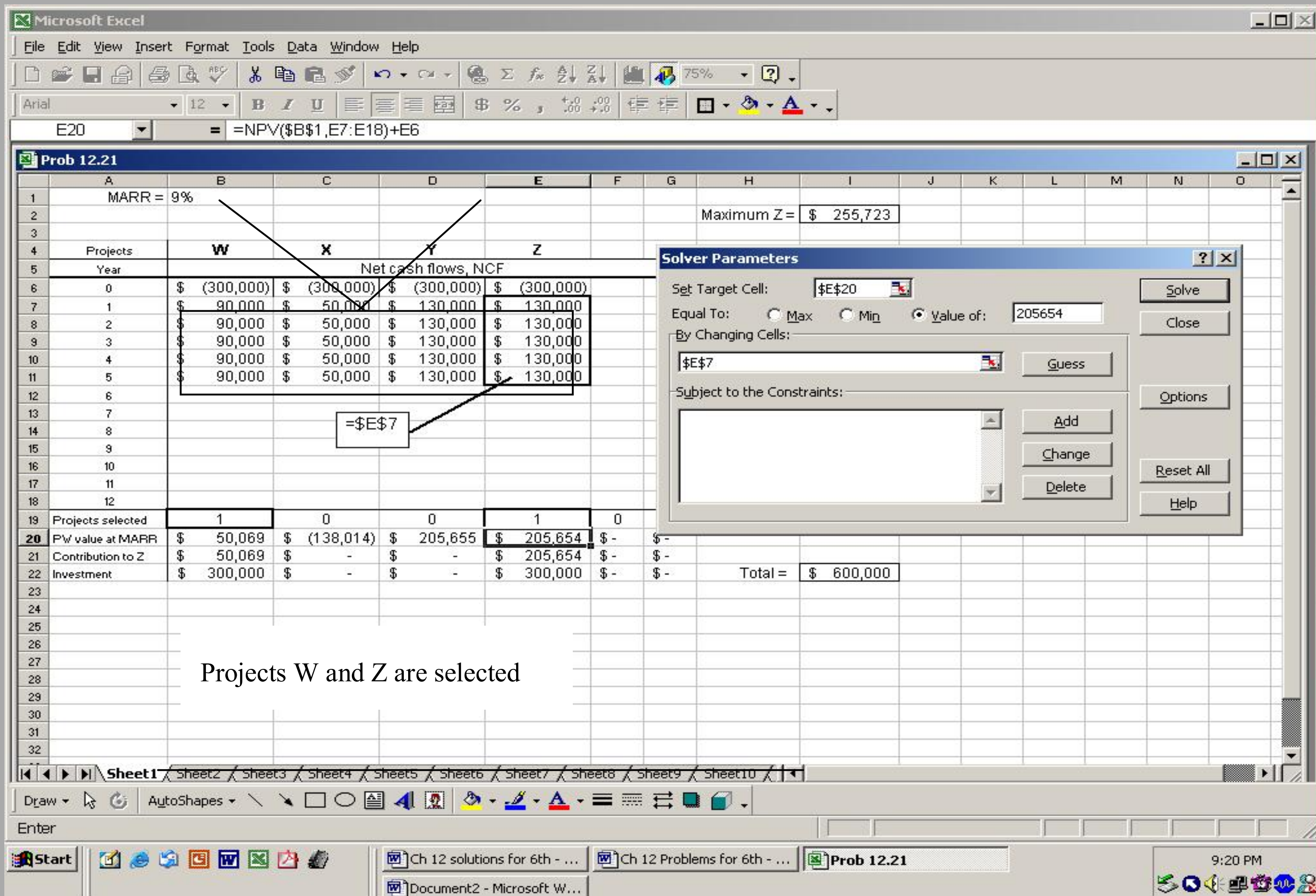


(b) To find MARR = 9.518% in cell B1, use SOLVER with target cell D12 value of 0 and changing cell B1. Be sure the options box on SOLVER for 'assume linear model' is not checked and that the tolerance % is small (see below).





12.21 SOLVER can be used 4 times. First to get the selection of WY with Z = \$255,723, or by simply observing that these have PW > 0 and the sum is this amount. Now it gets a little harder for the three 2-project selections of WZ, XZ, and YZ. Set up SOLVER for each selection with the target cell E20 as the difference 255,723 – NCF of the other project. For example, if W and Z are the projects, the required PW for Z is 255,723 – 50,069 = \$205,654. The SOLVER solution for WZ is shown here where the minimum NCF for Z is \$130,000 in the changing cell E7.

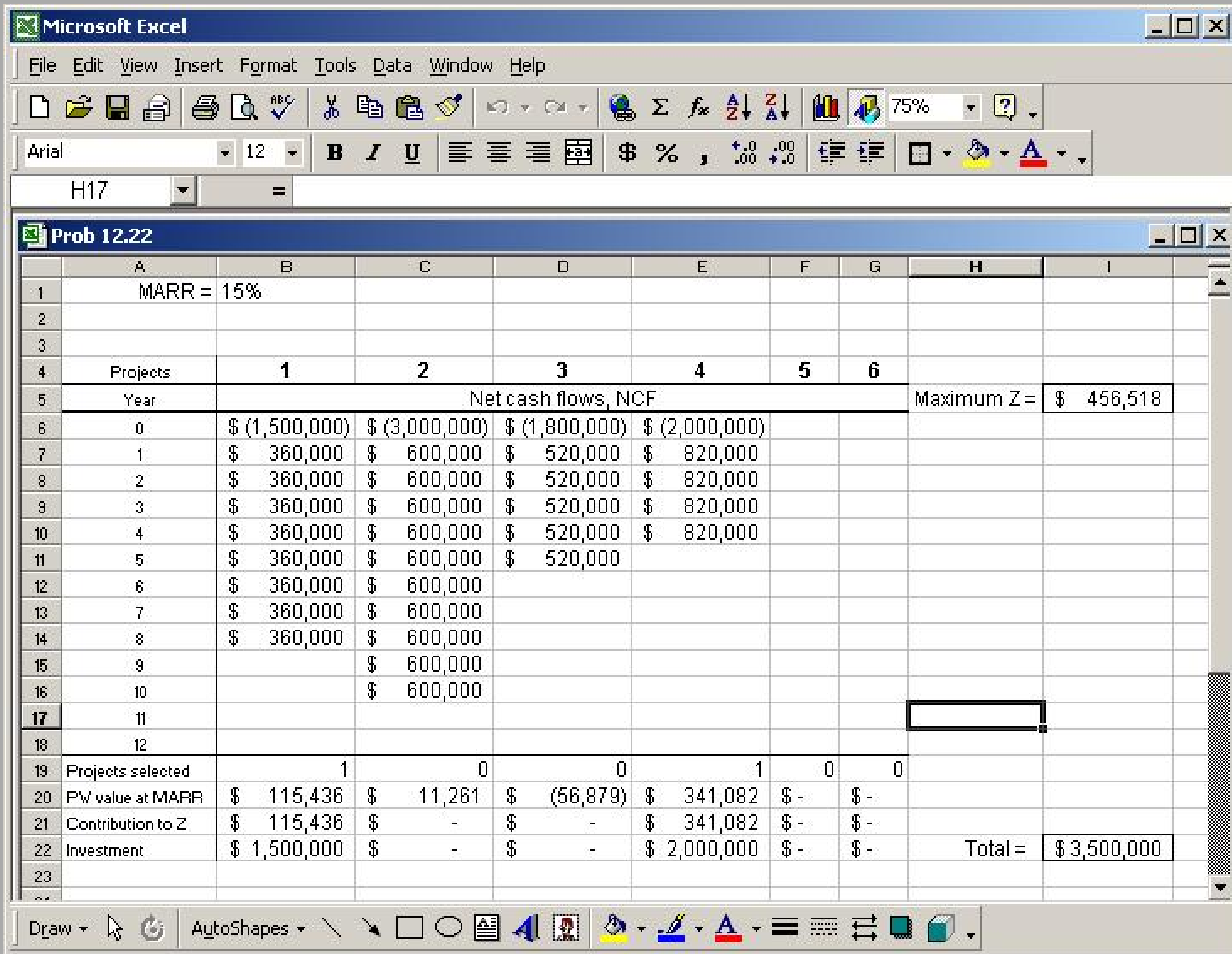


The 3 runs of SOLVER will generate the following results:

Projects	Target value in cell E20	Min NCF for Z
WZ	\$205,654	\$130,000
XZ	361,240	170,000
YZ	50,068	90,000

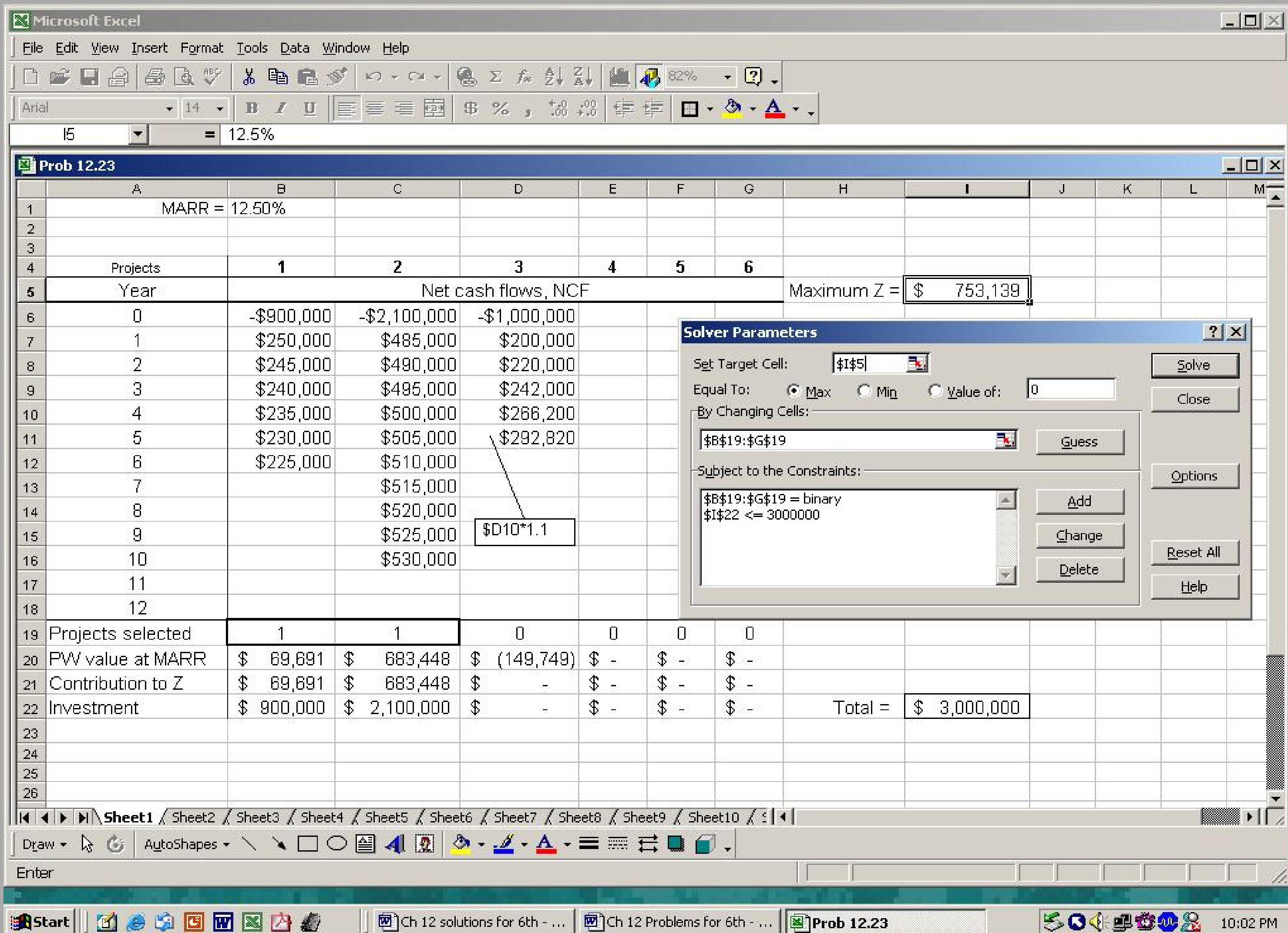
The minimum NCF for Z is, therefore, \$90,000 for the selection of the two projects Y and Z.

12.22 Use the capital budgeting problem template at 15% and a constraint on cell I22 of $4,000,000. Select projects 1 and 4 with $3.5 million invested and Z = $456,518.

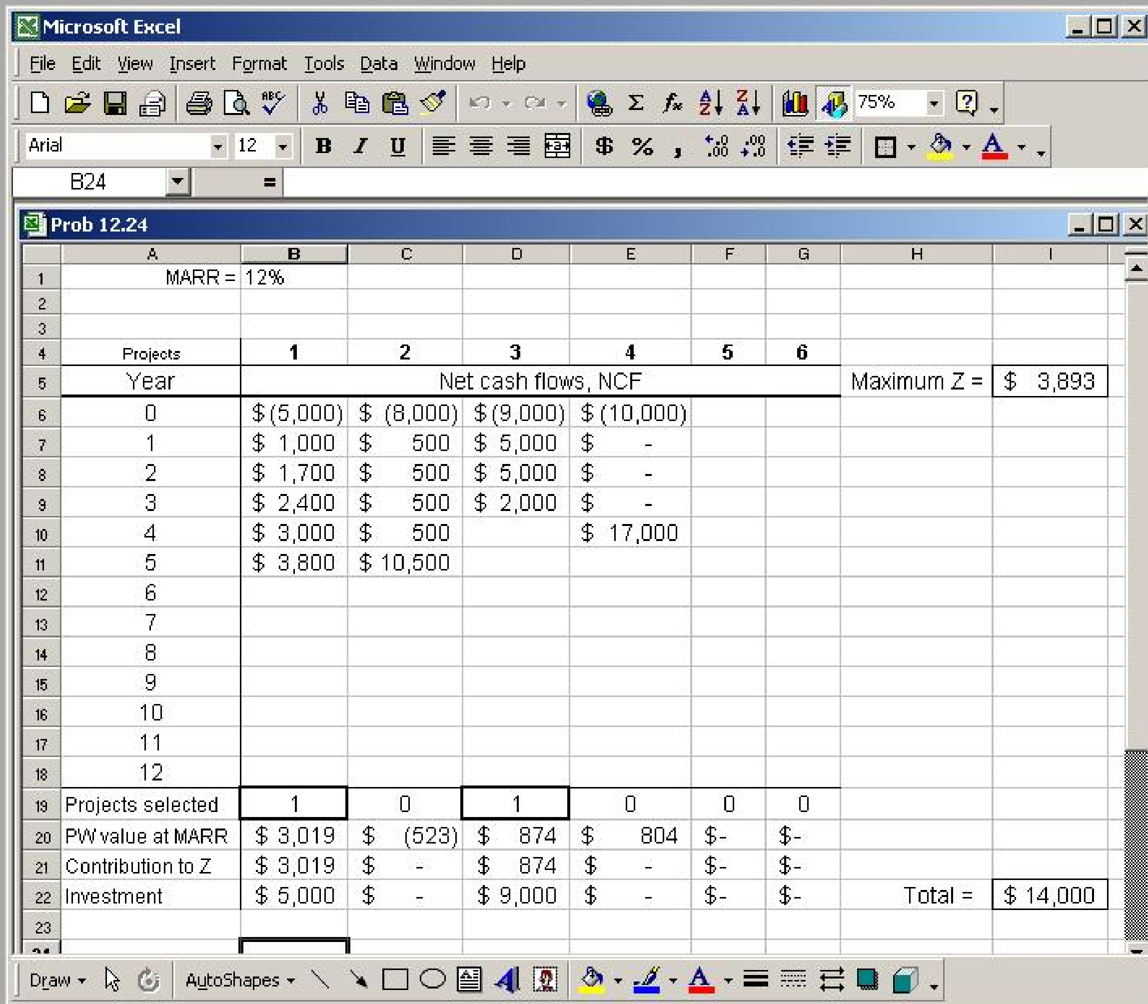


	A	B	C	D	E	F	G	H	I
1	MARR =	15%							
2									
3									
4	Projects	1	2	3	4	5	6		
5	Year	Net cash flows, NCF						Maximum Z =	$ 456,518
6	0	$ (1,500,000)	$ (3,000,000)	$ (1,800,000)	$ (2,000,000)				
7	1	$ 360,000	$ 600,000	$ 520,000	$ 820,000				
8	2	$ 360,000	$ 600,000	$ 520,000	$ 820,000				
9	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	$ 115,436	$ 11,261	$ (56,879)	$ 341,082	$ -	$ -		
21	Contribution to Z	$ 115,436	$ -	$ -	$ 341,082	$ -	$ -		
22	Investment	$ 1,500,000	$ -	$ -	$ 2,000,000	$ -	$ -	Total =	$ 3,500,000
23									

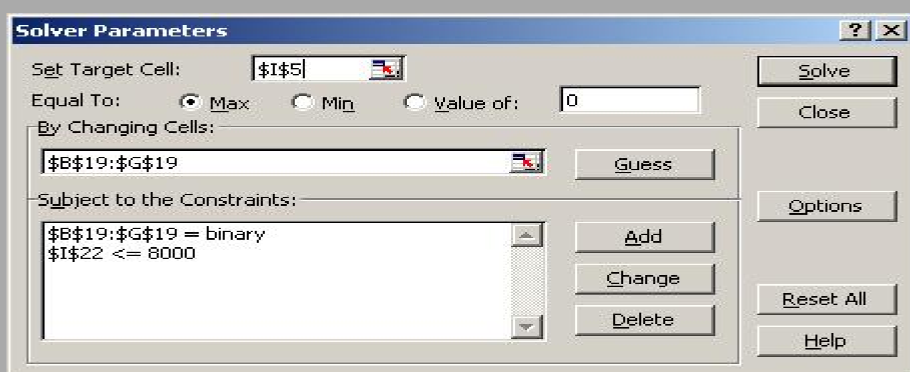
12.23 Enter the NCF values from Problem 12.14 into the capital budgeting template and b = $3,000,000 into SOLVER. Select projects 1 and 2 for Z = $753,139 with $3.0 million invested.



12.24 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 $14,000 invested, the same as in Problem 12.15 where all viable mutually exclusive bundles were evaluated by hand.



	A	B	C	D	E	F	G	H	I
1	MARR =	12%							
2									
3									
4	Projects	1	2	3	4	5	6		
5	Year	Net cash flows, NCF						Maximum Z =	$ 3,893
6	0	$(5,000)	$ (8,000)	$(9,000)	$(10,000)				
7	1	$ 1,000	$ 500	$ 5,000	$ -				
8	2	$ 1,700	$ 500	$ 5,000	$ -				
9	3	$ 2,400	$ 500	$ 2,000	$ -				
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	$-	$-		
21	Contribution to Z	$ 3,019	$ -	$ 874	$ -	$-	$-		
22	Investment	$ 5,000	$ -	$ 9,000	$ -	$-	$-	Total =	$ 14,000



12.25 Build a spreadsheet and use SOLVER repeatedly at increasing values of b to find the best projects and value of Z. Develop an Excel chart for the two series.

MARR = 12%

Projects	1	2	3	4	5	6		
Year	Net cash flows, NCF						Maximum Z =	$ 4,697
0	$ (5,000)	$ (8,000)	$ (9,000)	$ (10,000)				
1	$ 1,000	$ 500	$ 5,000	$ -				
2	$ 1,700	$ 500	$ 5,000	$ -				
3	$ 2,400	$ 500	$ 2,000	$ -				
4	$ 3,000	$ 500		$ 17,000				
5	$ 3,800	$ 10,500						
Projects selected	1	0	1	1	0	0		
PW value at MARR	$ 3,019	$ (523)	$ 874	$ 804	$-	$-		
Contribution to Z	$ 3,019	$ -	$ 874	$ 803.81	$-	$-		
Investment	$ 5,000	$ -	$ 9,000	$ 10,000	$-	$-	Total =	$ 24,000

Capital Budget, $	Value of Z, $	Project(s) Selected
$ 5,000	3019	1
$ 6,000	3019	1
$ 7,000	3019	1
$ 8,000	3019	1
$ 9,000	3019	1
$ 10,000	3019	1
$ 11,000	3019	1
$ 12,000	3019	1
$ 13,000	3019	1
$ 14,000	3893	1,3
$ 15,000	3893	1,3
$ 16,000	3893	1,3
$ 17,000	3893	1,3
$ 18,000	3893	1,3
$ 19,000	3893	1,3
$ 20,000	3893	1,3
$ 21,000	3893	1,3
$ 22,000	3893	1,3
$ 23,000	3893	1,3
$ 24,000	4697	1,3,4
$ 25,000	4697	1,3,4

Case Study Solution

(1) Rows 5 and 6 of the spreadsheet show the viable bundles for the $3.5 million spending limit and the project relationship.

(2) Projects B and C with PW = $895,000 are the economic choices. This commits only $2.2 million of the allowed $3.5 million.

	A	B	C	D	E	F	G	H	I	J
1										
2	MARR	10%	per 6-months							
3										
4	Bundle	1	2	3	4	5	6	7	8	9
5	Projects	**A**	**C**	**D**	**AC**	**AD**	**BC**	**CD**	**ABC**	**ACD**
6	Investment	$(1,000)	$ (200)	$(1,000)	$(1,200)	$(2,000)	$(2,200)	$(1,200)	$(3,200)	$(2,200)
7	Period				Net cash flows, NCF (X $1000)					
8	0	$ (500)	$ -	$ (300)	$ (500)	$ (800)	$(2,000)	$ (300)	$(2,500)	$ (800)
9	1	$ -	$ (200)	$ (300)	$ (200)	$ (300)	$ 300	$ (500)	$ 300	$ (500)
10	2	$ 100	$ 50	$ (100)	$ 150	$ -	$ 550	$ (50)	$ 650	$ 50
11	3	$ (300)	$ 100	$ 300	$ (200)	$ -	$ 700	$ 400	$ 400	$ 100
12	4	$ 400	$ 150	$ 300	$ 550	$ 700	$ 850	$ 450	$ 1,250	$ 850
13	5	$ 400	$ -	$ 300	$ 400	$ 700	$ 800	$ 300	$ 1,200	$ 700
14	6	$ -	$ -	$ 300	$ -	$ 300	$ 1,000	$ 300	$ 1,000	$ 300
15										
16	PW value	$ (121)	$ 37	$ 131	$ (84)	$ 9	$ 895	$ 168	$ 774	$ 46
17										
18	Overall i*/ 6-mth	3.8%	19.4%	15.5%	6.4%	10.2%	21.7%	16.1%	18.1%	11.0%
19										

(3) Change cash flows, investment amount, life, etc. to obtain a PW and overall i* greater than the results for BC (column G).

Chapter 13

Breakeven Analysis

Solutions to Problems

13.1 (a) Q_{BE} = 1,000,000/(8.50-4.25) = 235,294 units

(b) Profit = R – TC
= 8.50Q – 1,000,000 - 4.25Q

at 200,000 units: Profit = 8.50(200,000) – 1,000,000 - 4.25(200,000)
= \$-150,000 (loss)

at 350,000 units: Profit = \$487,500

For computer plot: Develop an Excel graph for different Q values using the relation:

Profit = 4.25Q – 1,000,000

13.2 One is linear and the other is parabolic. Another is two parabolic. The curves would have the intersecting at real number points to ensure the 2 breakeven points.

13.3 Set revenue at efficiency E equal to the total cost

$$12{,}000(E)(250) = 15{,}000{,}000(A/P,1\%, 20) + (4{,}100{,}000)E^{1.8}$$

$$3{,}000{,}000(E) = 15{,}000{,}000(0.01435) + (4{,}100{,}000)E^{1.8}$$

$$3{,}000{,}000(E) – 4{,}100{,}000E^{1.8} = 215{,}250$$

Solve for E by trial and error:

at E = 0.55: 252,227 > 215,250
at E = 0.57: 219,409 > 215,250
at E = 0.58: 202,007 < 215,250

E = 0.572 or 57.2% minimum removal efficiency

13.4 Using Equation [13.2] on a per month basis.

(a) $Q_{BE} = (4{,}000{,}000/12)/(39.95-24.75) = 333{,}333.3/15.2$
$= 21{,}930$ units/month

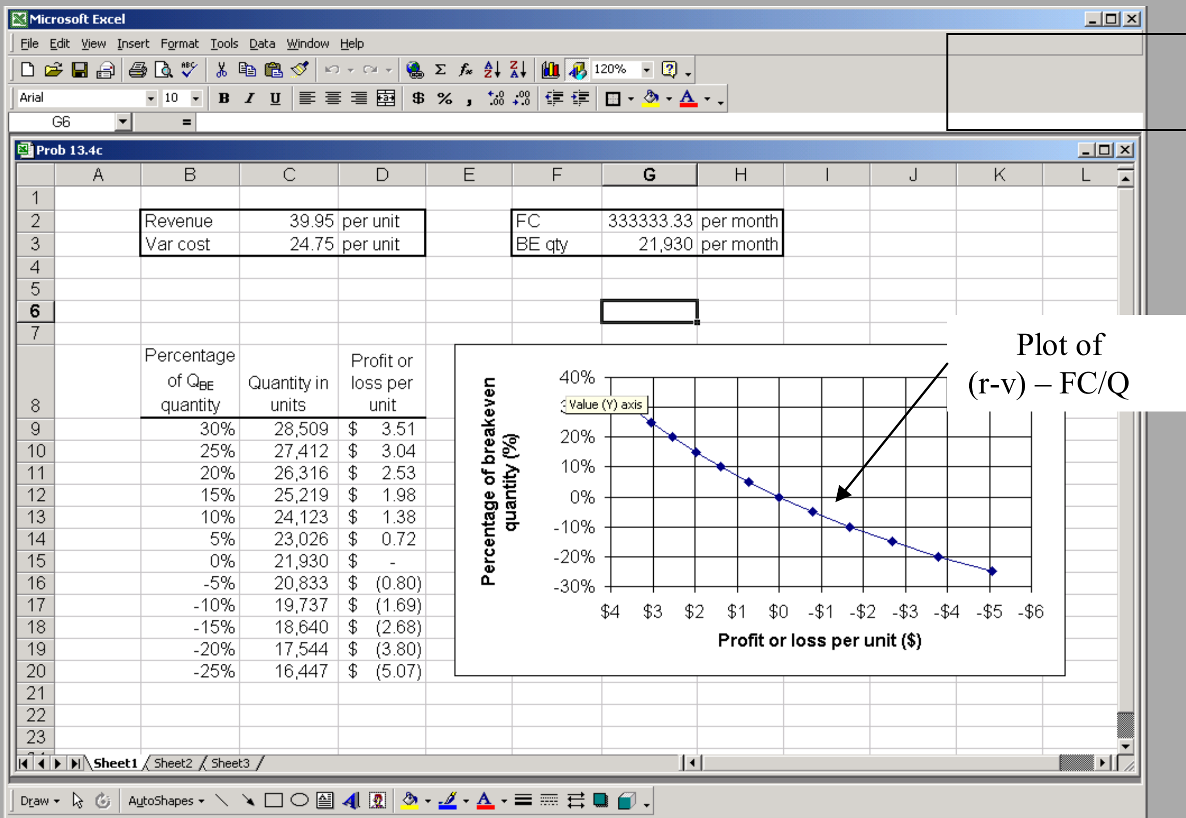
(b) In Equation [13.3] in Example 13.1 divide by Q to get profit (loss) per unit.

Profit (loss) = (r-v) – FC/Q

10% below Q_{BE} : Loss = (r-v) – FC/Q
= (39.95 – 24.75) – (333,333.3)/(21,930)(0.9)
= 15.20 – 16.89
= $-1.69 per unit

10% above Q_{BE} : Profit = (r-v) – FC/Q
= (39.95 – 24.75) – (333,333.3)/(21,930)(1,1)
= 15.20 – 13.82
= $ 1.38 per unit

(c) To plot the profit or loss per unit, use the equation in part (b).
Profit or loss = (r-v) – FC/Q



Revenue	39.95	per unit	
Var cost	24.75	per unit	

FC	333333.33	per month
BE qty	21,930	per month

Percentage of Q_{BE} quantity	Quantity in units	Profit or loss per unit
30%	28,509	$ 3.51
25%	27,412	$ 3.04
20%	26,316	$ 2.53
15%	25,219	$ 1.98
10%	24,123	$ 1.38
5%	23,026	$ 0.72
0%	21,930	$ -
-5%	20,833	$ (0.80)
-10%	19,737	$ (1.69)
-15%	18,640	$ (2.68)
-20%	17,544	$ (3.80)
-25%	16,447	$ (5.07)

13.5 From Equation [13.4], plot $C_u = 160{,}000/Q + 4$. Plot is shown below.

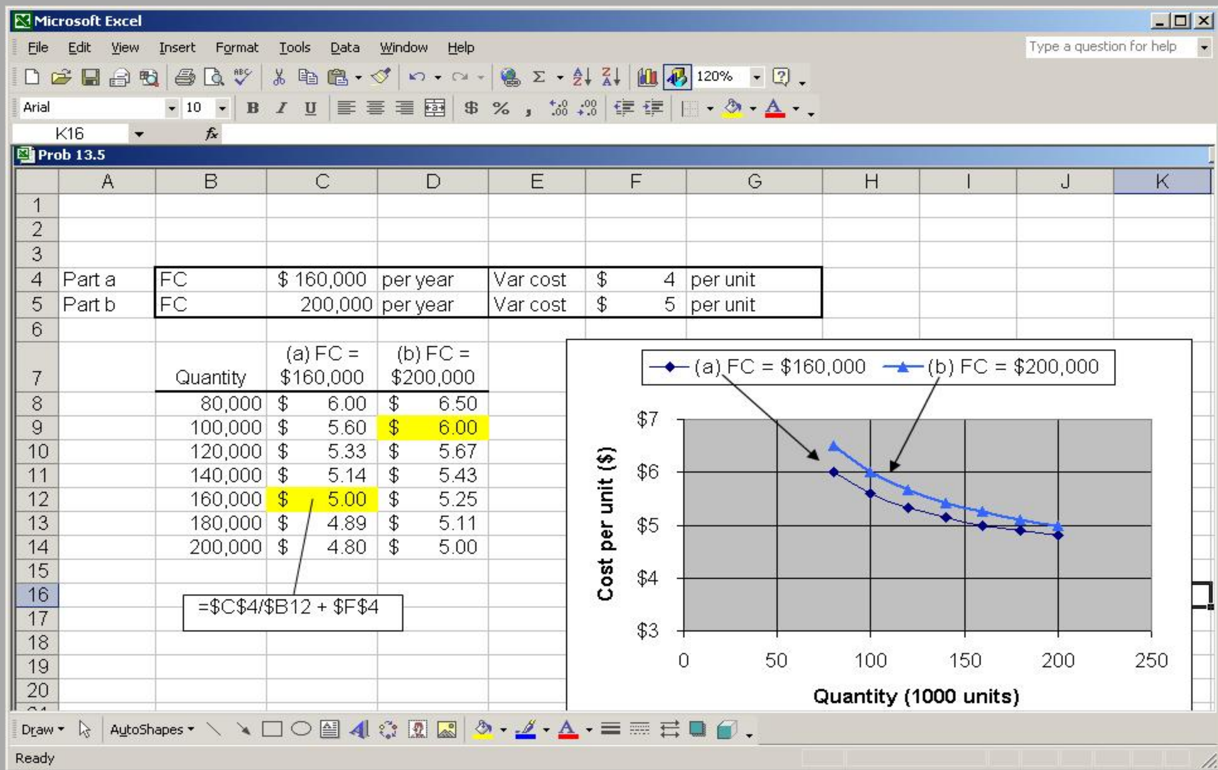
(a) If $C_u = \$5$, from the graph, Q is approximately 160,000. If Q is determined by Equation [13.4], it is

$$5 = 160{,}000/Q + 4$$
$$Q = 160{,}000/1 = 160{,}000 \text{ units}$$

(b) From the plot, or by equation, Q = 100,000 units.

$$C_u = 6 = 200{,}000/Q + 4$$

$$Q = 200{,}000/2 = 100{,}000 \text{ units}$$



	A	B	C	D	E	F	G
4	Part a	FC	$ 160,000	per year	Var cost	$ 4	per unit
5	Part b	FC	200,000	per year	Var cost	$ 5	per unit
7		Quantity	(a) FC = $160,000	(b) FC = $200,000			
8		80,000	$ 6.00	$ 6.50			
9		100,000	$ 5.60	$ 6.00			
10		120,000	$ 5.33	$ 5.67			
11		140,000	$ 5.14	$ 5.43			
12		160,000	$ 5.00	$ 5.25			
13		180,000	$ 4.89	$ 5.11			
14		200,000	$ 4.80	$ 5.00			

13.6 (a) $$Q_{BE} = \frac{775{,}000}{3.50 - 2} = 516{,}667 \text{ calls per year}$$

This is 37% of the center's capacity

(b) Set Q_{BE} = 500,000 and determine r at v = \$2 and FC = 0.5(900,000).

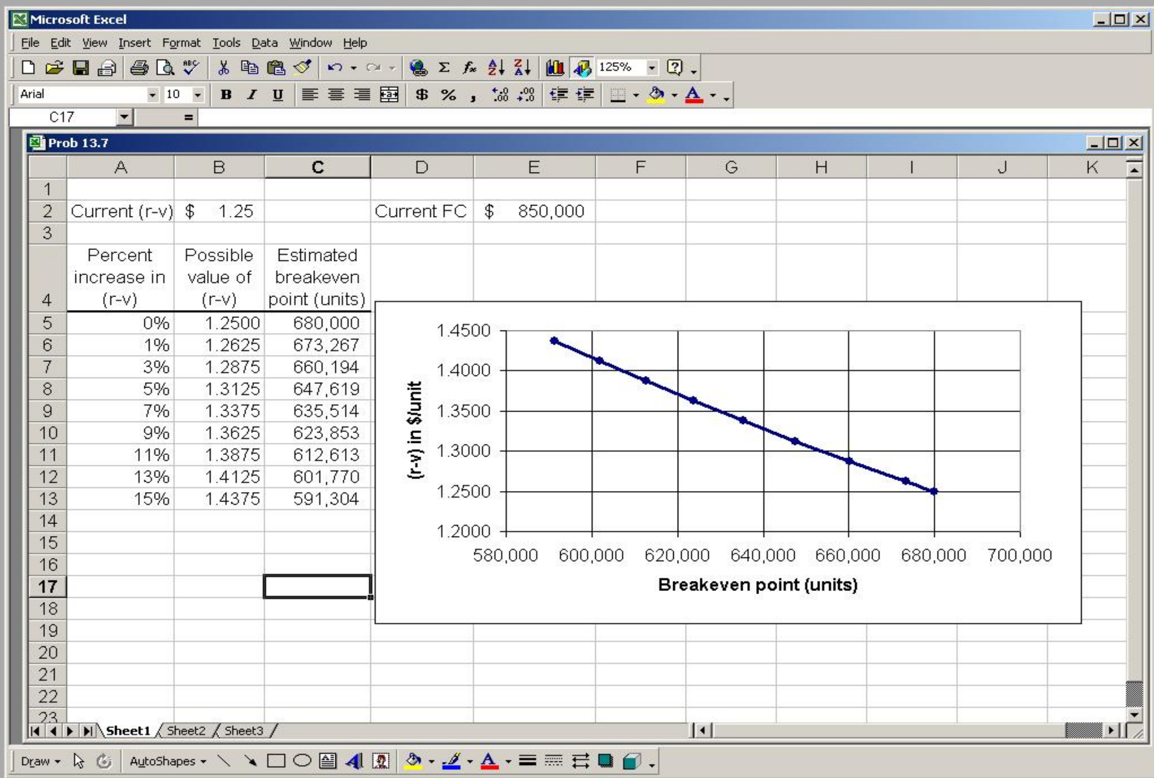
$$500{,}000 = \frac{450{,}000}{r - 2}$$

$$r - 2 = \frac{450{,}000}{500{,}000}$$

$$r = 0.9 + 2 = \$2.90 \text{ per call}$$

Average revenue required for the new product only is 60 cents per call lower.

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

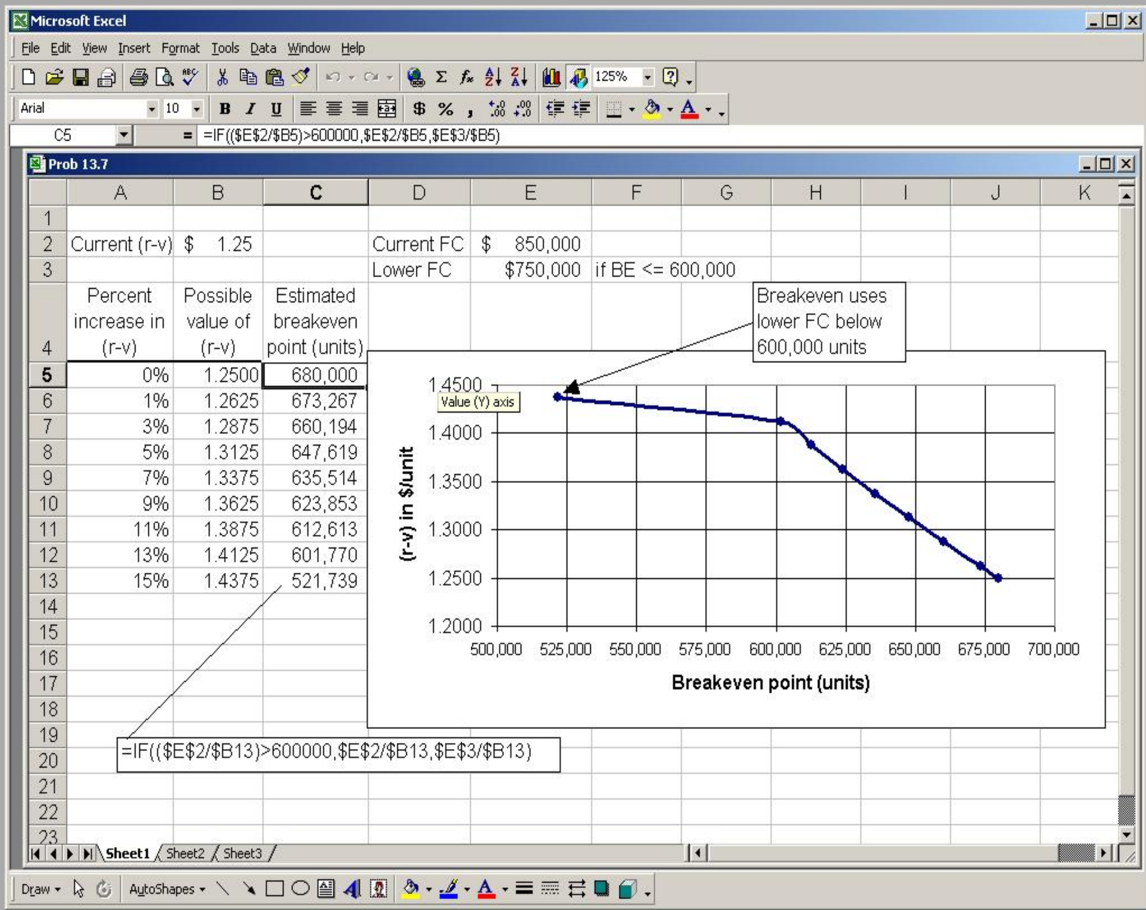


Current (r-v)	$ 1.25		Current FC	$ 850,000

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. If r and FC are constant, this means all the reduction must take place in a **lower variable cost per unit**.

13.8 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.



C5 =IF(($E$2/$B5)>600000,$E$2/$B5,$E$3/$B5)

	A	B	C	D	E	F
2	Current (r-v)	\$ 1.25		Current FC	\$ 850,000	
3				Lower FC	\$750,000	if BE <= 600,000
4	Percent increase in (r-v)	Possible value of (r-v)	Estimated breakeven point (units)			
5	0%	1.2500	680,000			
6	1%	1.2625	673,267			
7	3%	1.2875	660,194			
8	5%	1.3125	647,619			
9	7%	1.3375	635,514			
10	9%	1.3625	623,853			
11	11%	1.3875	612,613			
12	13%	1.4125	601,770			
13	15%	1.4375	521,739			

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.

13.9 Let x = gradient increase per year. Set revenue = cost.

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

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

$$x = 2110 \text{ cars/year increase}$$

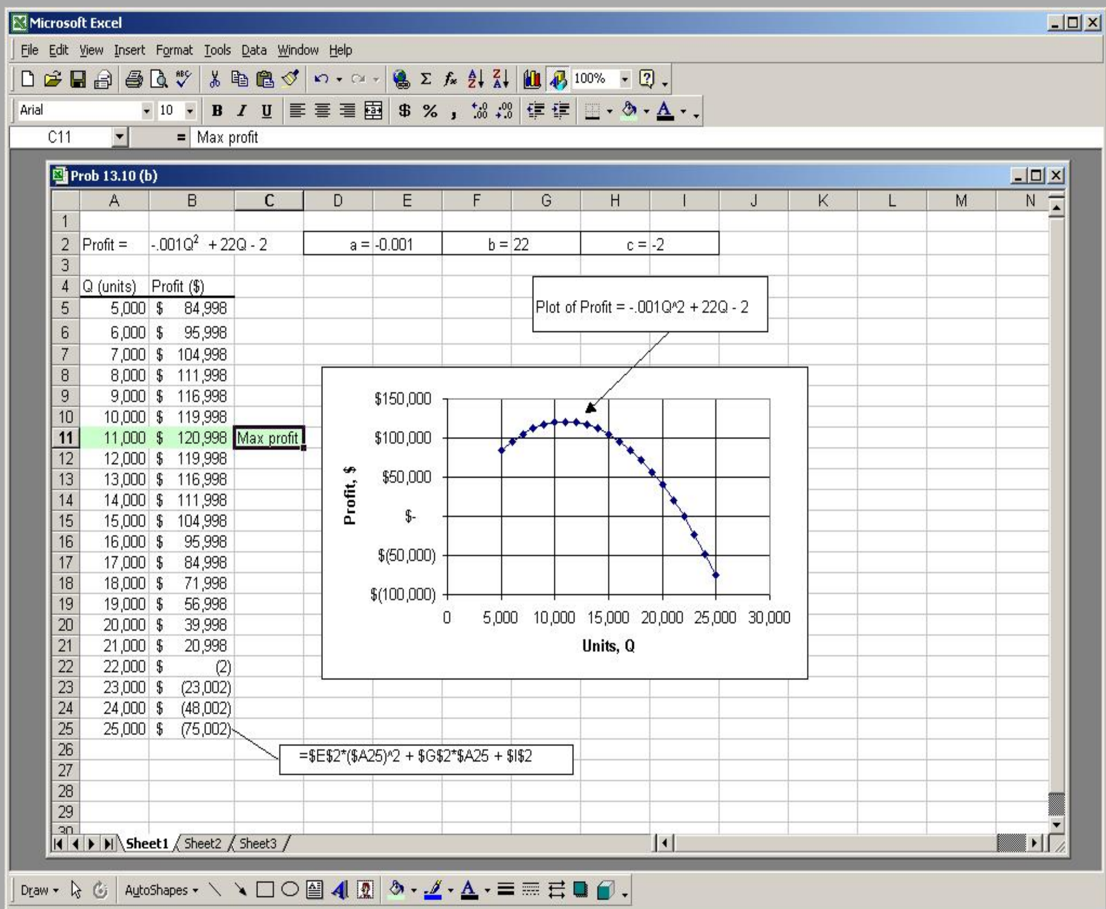
13.10 (a) $\text{Profit} = R - TC = 25Q - 0.001Q^2 - 3Q - 2$

$$= -0.001Q^2 + 22Q - 2$$

Q	Profit (approximate)
5,000	\$ 85,000
10,000	120,000
11,000	121,000
15,000	105,000
20,000	40,000
25,000	-75,000

About 11,000 cases per year is breakeven with profit of \$121,000.

(b) Develop the Excel graph for Q vs Profit = $-0.001Q^2 + 22Q - 2$ that indicates a max profit of \$120,998 at Q = 11,000 units.



(c) In general, Profit = R - TC = $aQ^2 + bQ + c$

The a, b and c are constants. Take the first derivative, set equal to 0, and solve.

$Q_{max} = -b/2a$

Substitute into the profit relation.

$Profit_{max} = (-b^2/4a) + c$

Here, $Q_{max} = 22/2(0.001)$
$= 11{,}000$ cases per year

$Profit_{max} = [-(22)^2/4(-0.001)] - 2$
$= \$120{,}998$ per year

13.11 FC = \$305,000 v = \$5500/unit

(a) Profit = (r – v)Q – FC

$0 = (r - 5500)5000 - 305{,}000$
$(r - 5500) = 305{,}000 / 5000$
$r = 61 + 5500$
$= \$5561$ per unit

(b) Profit = (r – v)Q – FC

$500{,}000 = (r - 5500)8000 - 305{,}000$
$(r - 5500) = (500{,}000 + 305{,}000) / 8000$
$r = \$5601$ per unit

13.12 Let x = ads per year

$-12{,}000(A/P,8\%,3) - 45{,}000 + 2000(A/F,8\%,3) - 8x = -20x$
$-12{,}000(0.38803) - 45{,}000 + 2000(0.30803) = -12x$
$-49{,}040 = -12x$

$x = 4087$ ads per year

At 4000 ads per year, select the outsource option at \$20 per ad for a total cost of \$80,000 versus the inhouse option cost of \$49,040 +8(4000) = \$81,040.

13.13 Let n = number of months

$$-15{,}000(A/P, 0.5\%, n) - 80 = -1000$$
$$-15{,}000(A/P, 0.5\%, n) = -920$$
$$(A/P, 0.5\%, n) = 0.0613$$

n is approximately 17 months

13.14 Let x = hours per year

$$-800(A/P,10\%,3) - (300/2000)x - 1.0x = -1{,}900(A/P,10\%,5) - (700/8000)x - 1.0x$$

$$-800(0.40211) - 0.15x - 1.0x = -1{,}900(0.2638) - 0.0875x - 1.0x$$

$$0.0625x = 179.532$$
$$x = 2873 \text{ hours per year}$$

13.15 Set $AW_1 = AW_2$ where P_2 = first cost of Proposal 2. The final term in AW_2 removes the repainting cost in year 8.

$$-250{,}000(A/P,12\%,4) - 3{,}000 = -P_2(A/P,12\%,8) - 3{,}000(A/F,12\%,2) + 3{,}000(A/F,12\%,8)$$

$$-250{,}000(0.32923) - 3{,}000 = -P_2(0.2013) - 3{,}000(0.4717) + 3{,}000(0.0813)$$

$$-85{,}307.50 = -P_2(0.2013) - 1171.20$$
$$-84{,}136.30 = -P_2(0.2013)$$
$$P_2 = \$417{,}965$$

13.16 Let x = production in year 4. Determine variable costs in year 4 and set the cost relations equal. The 10% interest rate is not needed.

$$-400{,}000 - 86x = -750{,}000 - 62x$$
$$24x = 350{,}000$$
$$x = 14{,}584 \text{ units}$$

13.17 (a) Let x = breakeven days per year. Use annual worth analysis.

$$-125{,}000(A/P,12\%,8) + 5{,}000(A/F,12\%,8) - 2{,}000 - 40x = -45(125 + 20x)$$
$$-125{,}000(0.2013) + 5{,}000(0.0813) - 2{,}000 - 40x = -5625 - 900x$$
$$-26{,}756 - 40x = -5625 - 900x$$
$$-21{,}131 = -860x$$
$$x = 24.6 \text{ days per year}$$

(b) Since 75 > 24.6 days, select the buy. Annual cost is

$$-26{,}756 - 40(75) = \$-29{,}756$$

13.18 Let FC_B = fixed cost for B. Set total cost relations equal at 2000 units per year.

Variable cost for B = 2000/200 = $10/unit

$$40{,}000 + 60(2000 \text{ units}) = FC_B + 10(2000 \text{ units})$$

$$FC_B = \$140{,}000 \text{ per year}$$

13.19 (a) Let x = days per year to pump the lagoon. Set the AW relations equal.

$$-800(A/P,10\%,8) - 300x = -1600(A/P,10\%,10) - 3x - 12(8200)(A/P,10\%,10)$$

$$-800(0.18744) - 300x = -1600(0.16275) - 3x - 98{,}400(0.16275)$$
$$-149.95 - 300x = -16275 - 3x$$
$$297x = 16125.05$$

$$x = 54.3 \text{ days per year}$$

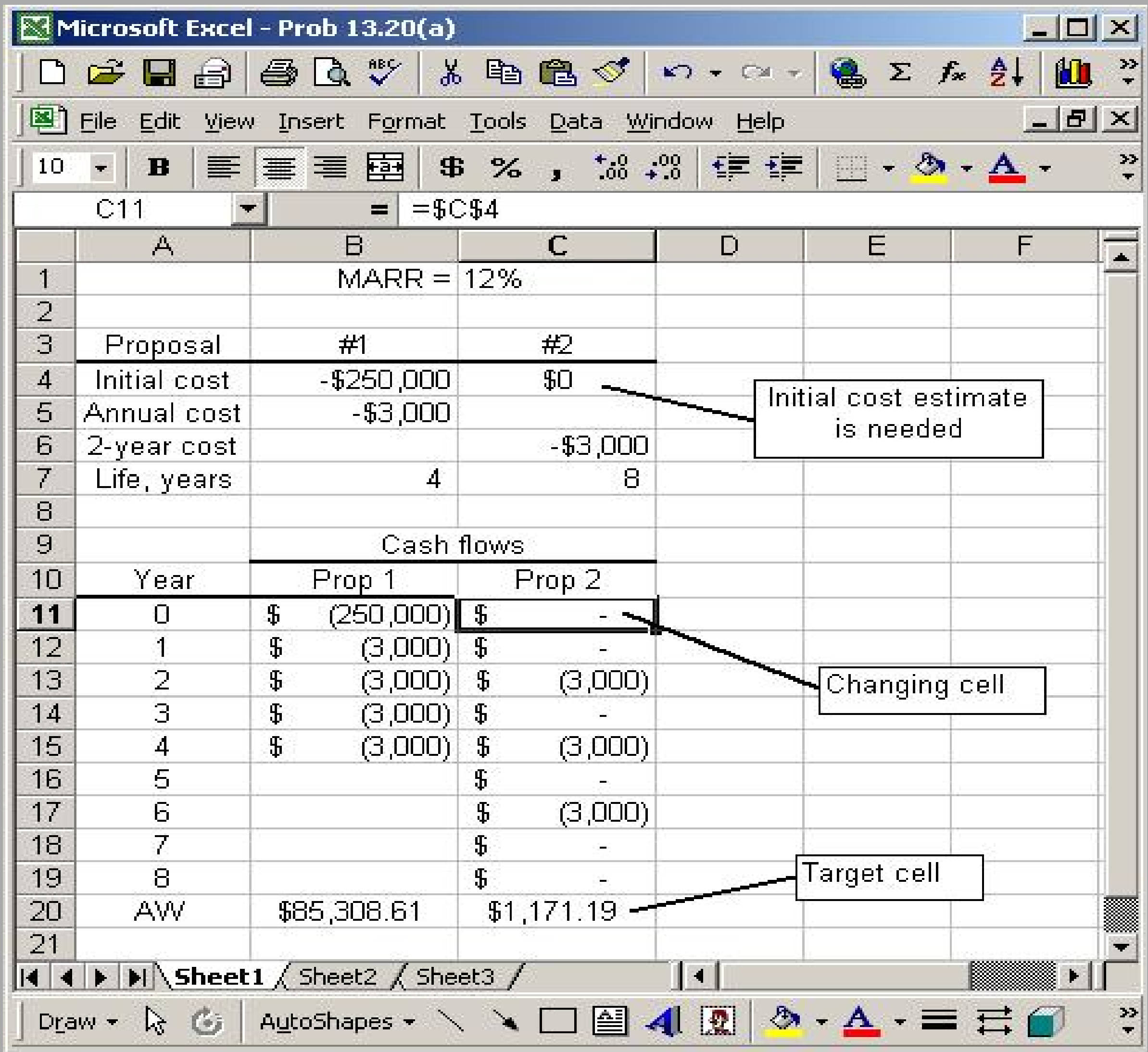
(b) If the lagoon is pumped 52 times per year and P = cost of pipeline, the breakeven equation in (a) becomes:

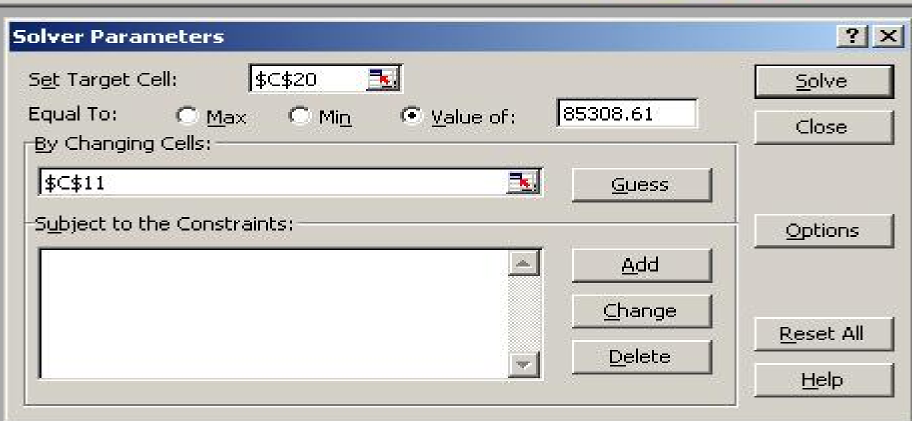
$$-800(0.18744) - 300(52) = -1600(0.16275) - 3(52) + P\,(0.16275)$$

$$-15{,}750 = -416.4 + 0.16275P$$

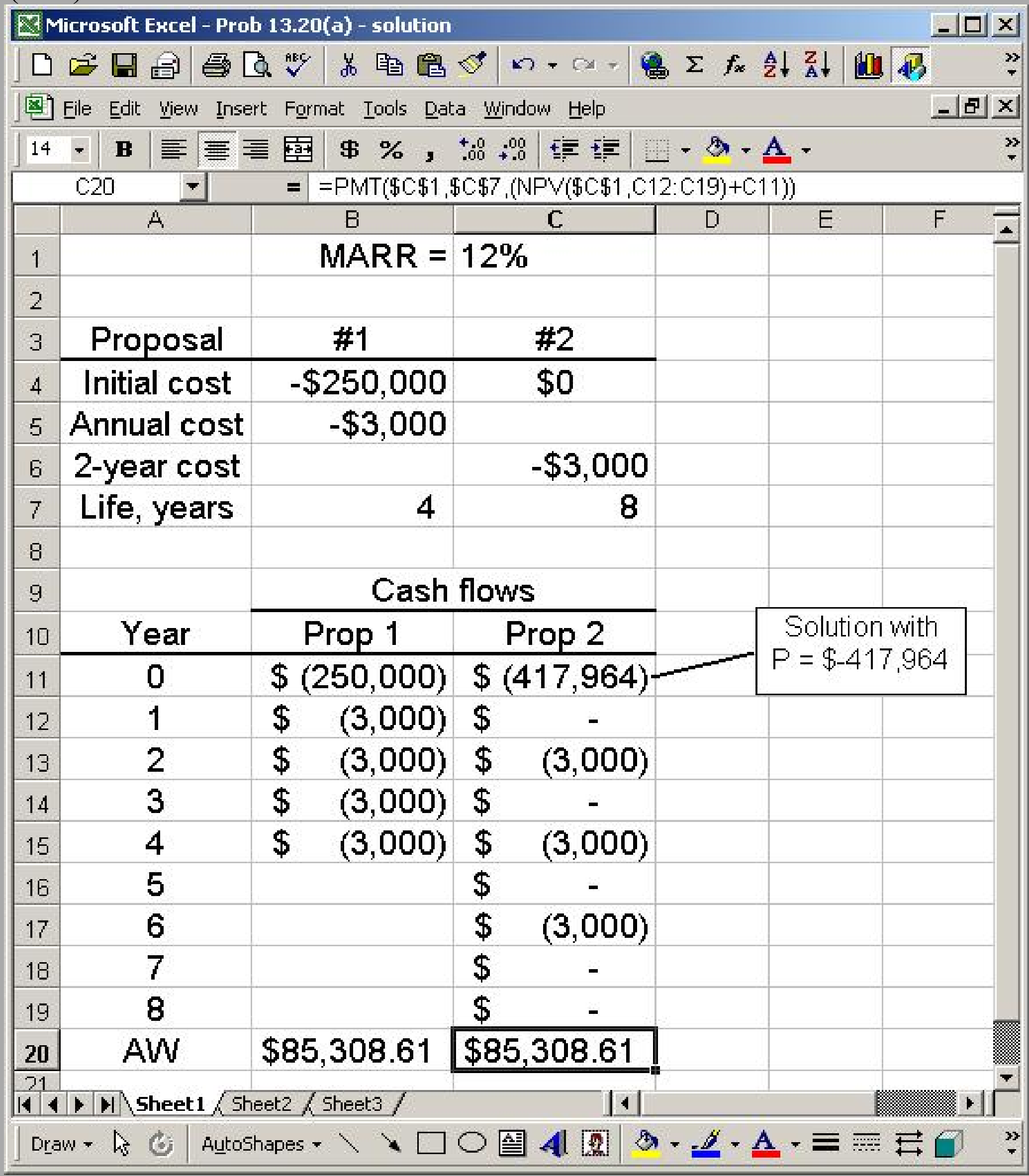
$$P = \$-94{,}216$$

13.20 (a) Excel spreadsheet, SOLVER entries, and solution for P = -$417,964 are below.


Microsoft Excel - Prob 13.20(a)
File Edit View Insert Format Tools Data Window Help
C11
= =$C$4
MARR = 12%
Proposal #1 #2
Initial cost -$250,000 $0
Annual cost -$3,000
2-year cost -$3,000
Life, years 4 8
Cash flows
Year Prop 1 Prop 2
0 $ (250,000) $ -
1 $ (3,000) $ -
2 $ (3,000) $ (3,000)
3 $ (3,000) $ -
4 $ (3,000) $ (3,000)
5 $ -
6 $ (3,000)
7 $ -
8 $ -
AW $85,308.61 $1,171.19
Initial cost estimate is needed
Changing cell
Target cell
Sheet1 Sheet2 Sheet3
Draw AutoShapes


Solver Parameters
Set Target Cell: $C$20
Equal To: Max Min Value of: 85308.61
By Changing Cells:
$C$11
Guess
Subject to the Constraints:
Add
Change
Delete
Solve
Close
Options
Reset All
Help

13.20 (a) (cont)

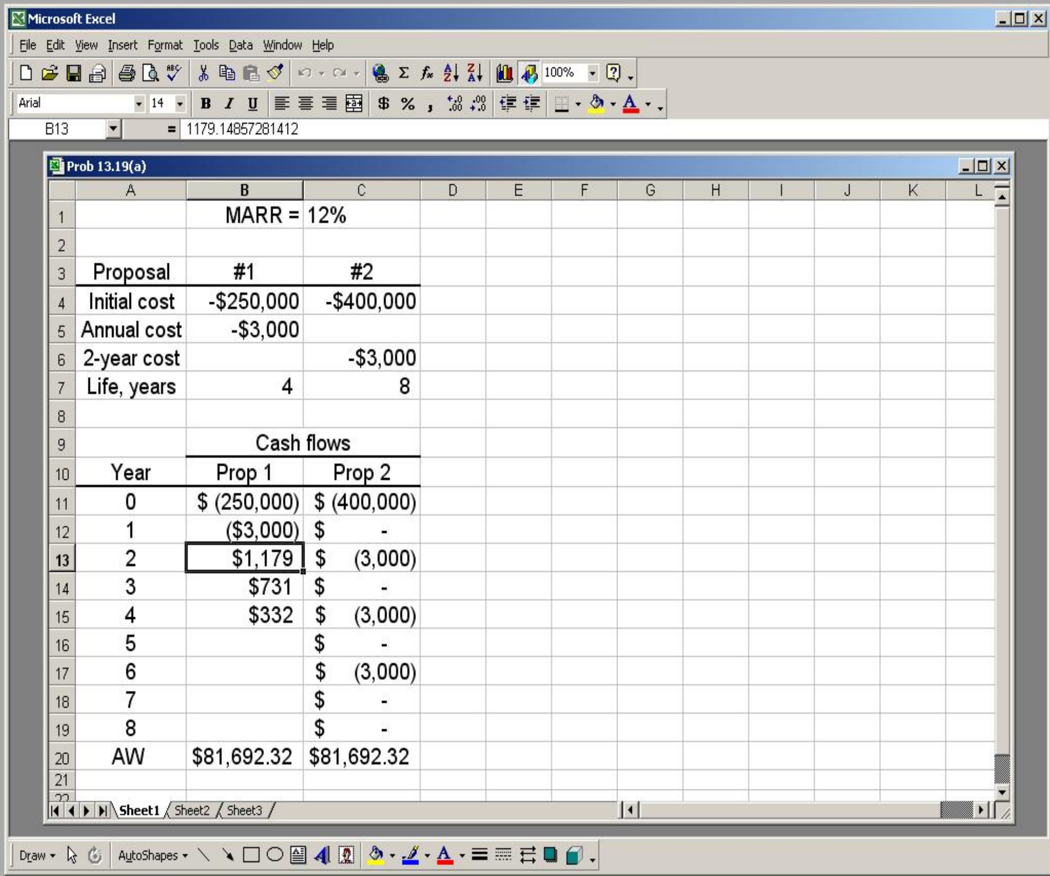

Microsoft Excel - Prob 13.20(a) - solution

C20 = =PMT($C$1,$C$7,(NPV($C$1,C12:C19)+C11))

	A	B	C
1		MARR =	12%
2			
3	Proposal	#1	#2
4	Initial cost	-$250,000	$0
5	Annual cost	-$3,000	
6	2-year cost		-$3,000
7	Life, years	4	8
8			
9		Cash flows	
10	Year	Prop 1	Prop 2
11	0	$ (250,000)	$ (417,964)
12	1	$ (3,000)	$ -
13	2	$ (3,000)	$ (3,000)
14	3	$ (3,000)	$ -
15	4	$ (3,000)	$ (3,000)
16	5		$ -
17	6		$ (3,000)
18	7		$ -
19	8		$ -
20	AW	$85,308.61	$85,308.61

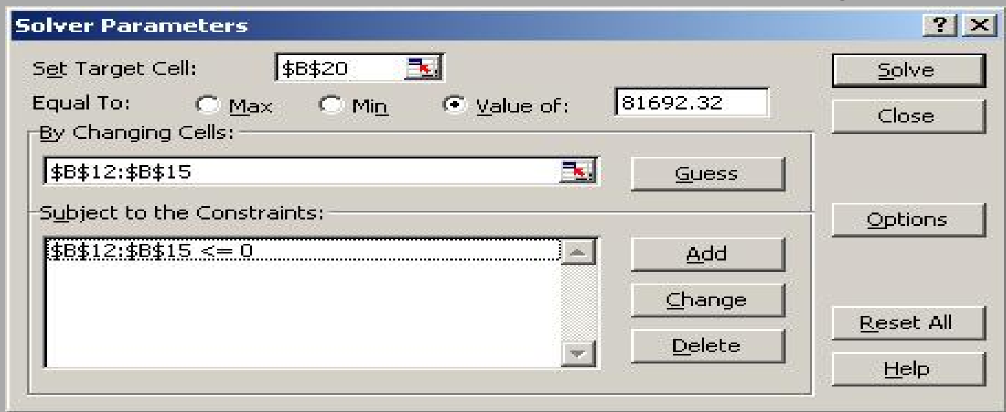
Solution with P = $-417,964

13.20 (b) Set cell C2 to –$400,000. The changing cells in SOLVER are B12 through B15. If no constraints are placed on the annual cash flows for proposal 1, the SOLVER solution has positive annual ‘costs’ in years 2, 3 and 4, which are not acceptable. The answer is ‘no’.



	A	B	C
1		MARR =	12%
2			
3	Proposal	#1	#2
4	Initial cost	-$250,000	-$400,000
5	Annual cost	-$3,000	
6	2-year cost		-$3,000
7	Life, years	4	8
8			
9		Cash flows	
10	Year	Prop 1	Prop 2
11	0	$ (250,000)	$ (400,000)
12	1	($3,000)	$ -
13	2	$1,179	$ (3,000)
14	3	$731	$ -
15	4	$332	$ (3,000)
16	5		$ -
17	6		$ (3,000)
18	7		$ -
19	8		$ -
20	AW	$81,692.32	$81,692.32

If constraints are made using SOLVER for cells B12 through B15 to not become positive, SOLVER finds no solution for break even. The answer, again, is 'no'.



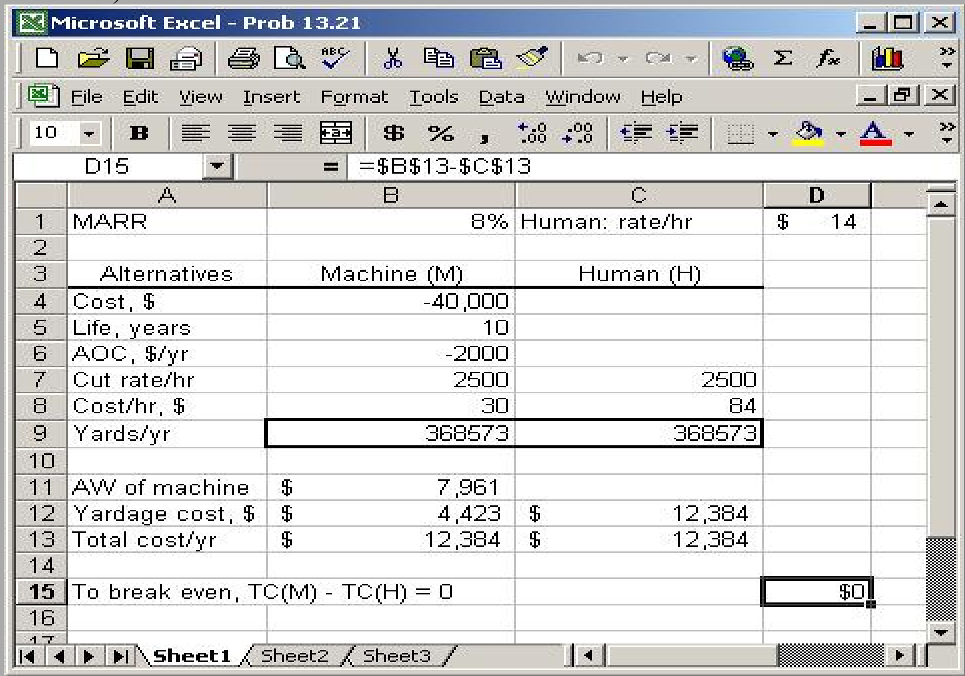
13.21 Let x = yards per year to breakeven

(a) Solution by hand

$$-40{,}000(A/P,8\%,10) - 2{,}000 - (30/2500)x = -[6(14)/2500]x$$
$$-40{,}000(0.14903) - 2{,}000 - 0.012x = -0.0336x$$
$$-7961.20 = -0.0216x$$
$$x = 368{,}574 \text{ yards per year}$$

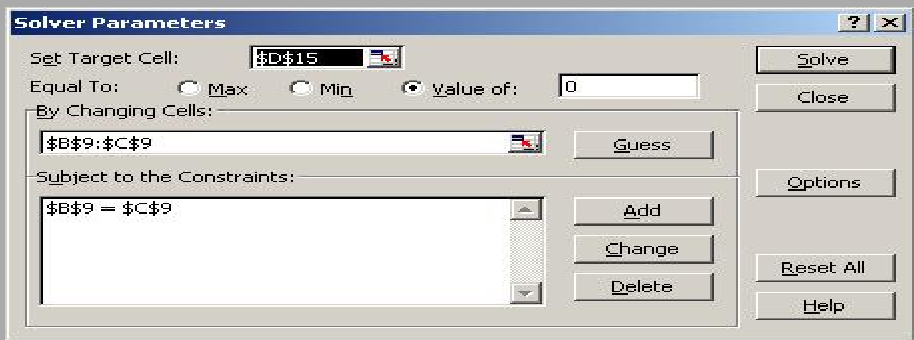
(b) Solution by computer

There are many Excel set-ups to work the problem. One is: Enter the parameters for each alternative, including some number of yards per year as a guess. Use SOLVER to force the breakeven equation (target cell D15) to equal 0, with a constraint in SOLVER that total yardage be the same for both alternatives (cell B9 = C9).

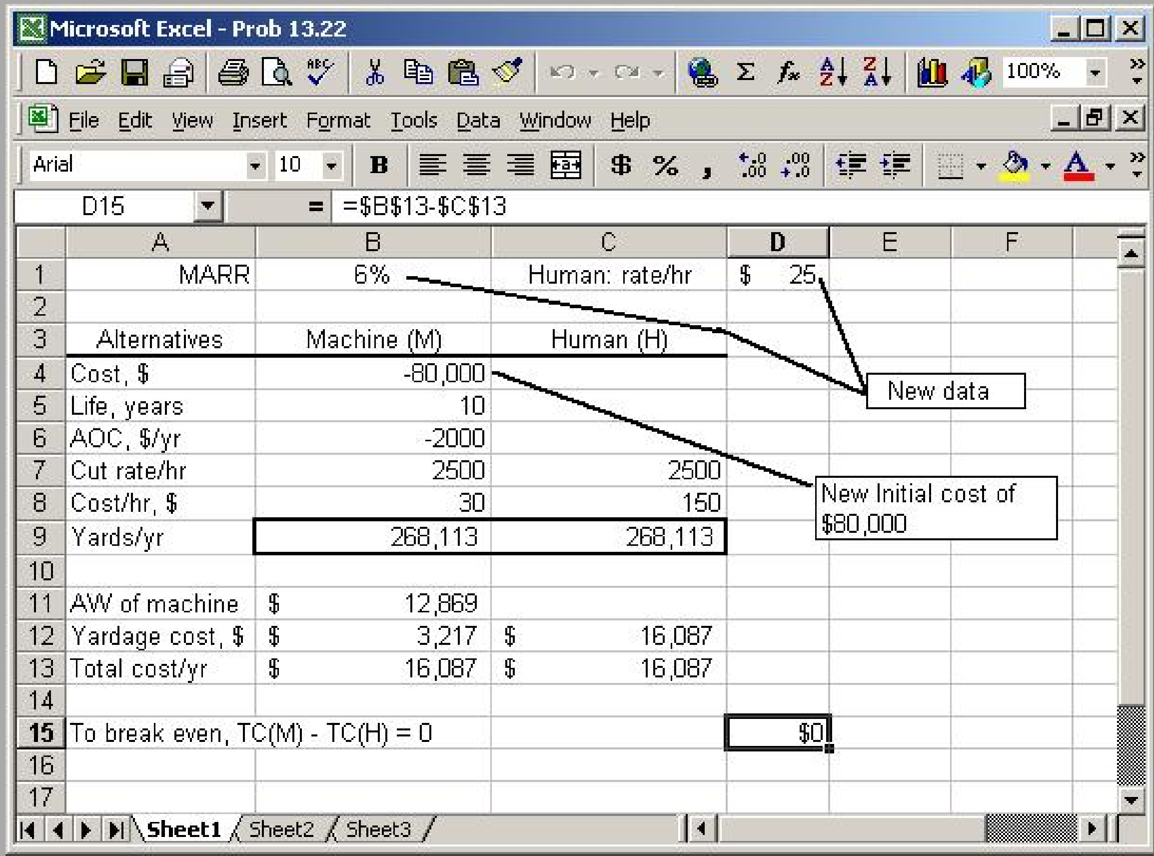

Microsoft Excel - Prob 13.21

D15 = =$B$13-$C$13

	A	B	C	D
1	MARR	8%	Human: rate/hr	$ 14
2				
3	Alternatives	Machine (M)	Human (H)	
4	Cost, $	-40,000		
5	Life, years	10		
6	AOC, $/yr	-2000		
7	Cut rate/hr	2500	2500	
8	Cost/hr, $	30	84	
9	Yards/yr	368573	368573	
10				
11	AW of machine	$ 7,961		
12	Yardage cost, $	$ 4,423	$ 12,384	
13	Total cost/yr	$ 12,384	$ 12,384	
14				
15	To break even, TC(M) - TC(H) = 0			$0
16				



13.22 Put in new values, use the Same SOLVER screen and obtain B_E = 268,113 yards/year.



Microsoft Excel - Prob 13.22

D15 = =$B$13-$C$13

	A	B	C	D	E	F
1	MARR	6%	Human: rate/hr	$ 25		
2						
3	Alternatives	Machine (M)	Human (H)			
4	Cost, $	-80,000				
5	Life, years	10				
6	AOC, $/yr	-2000				
7	Cut rate/hr	2500	2500			
8	Cost/hr, $	30	150			
9	Yards/yr	268,113	268,113			
10						
11	AW of machine	$ 12,869				
12	Yardage cost, $	$ 3,217	$ 16,087			
13	Total cost/yr	$ 16,087	$ 16,087			
14						
15	To break even, TC(M) - TC(H) = 0			$0		
16						
17						

Since now the annual yardage rate of 300,000 > 268,113, the lower variable cost alternative of the machine should be selected.

13.23 (a) Let n = number of years. Develop the relation

$$AW_{own} + AW_{lease} + AW_{sell} = 0$$

$$-(100{,}000 + 12{,}000)(A/P,8\%,n) - 3800 - 2500 - [1000(P/F,8\%,k)](A/P,8\%,n) + 12{,}000 + (60 + 1.5n)(2{,}500)(A/F,8\%,n) = 0$$

where k = 6, 12, 18, ..., and $k \leq n$.

Use trial and error to determine the breakeven n value.

n = 14: $-112{,}000(0.12130) + 5700 - [1000(0.6302 + 0.3971)](0.12130) + [60 + 1.5(14)](2{,}500)(0.04130) \mathrel{?}= 0$

$$-13{,}586 + 5700 - 125 + 8363 = \$+352 > 0$$

n = 16: $-112{,}000\,(0.11298) + 5700 - [1000(0.6302 + 0.3971)](0.11298) + [60 + 1.5(16)]\,(2{,}500)\,(0.03298) \overset{?}{=} 0$

$-12{,}654 + 5700 - 116 + 6926 = \$-144 < 0$

By interpolation, n = 15.42 years

Selling price = [60 + 1.5(15.42)] (2,500)
= $207,825

(b) Enter the cash flows and carefully develop the PW relations for each column. Breakeven is between 15 and 16 years. Selling price is estimated to be between $206,250 and $210,000. Linear interpolation can be used as in the manual trial and error method above.

Microsoft Excel - Prob 13.23(b)

A21 = 16

	A	B	C	D	E	F	G	H
1			MARR	8%				
2								
3				PW own + lease	Total PW	Estimated		Total
4	Year	Own	Lease	only	own + lease	selling price	PW sell	PW
5	0	-112000						
6	1	-6300	12000	$ 5,278	$ (106,722)	$ 153,750	$142,361	$ 35,639
7	2	-6300	12000	$ 10,165	$ (101,835)	$ 157,500	$135,031	$ 33,195
8	3	-6300	12000	$ 14,689	$ (97,311)	$ 161,250	$128,005	$ 30,695
9	4	-6300	12000	$ 18,879	$ (93,121)	$ 165,000	$121,280	$ 28,159
10	5	-6300	12000	$ 22,758	$ (89,242)	$ 168,750	$114,848	$ 25,607
11	6	-7300	12000	$ 25,720	$ (86,280)	$ 172,500	$108,704	$ 22,425
12	7	-6300	12000	$ 29,046	$ (82,954)	$ 176,250	$102,840	$ 19,886
13	8	-6300	12000	$ 32,126	$ (79,874)	$ 180,000	$97,248	$ 17,374
14	9	-6300	12000	$ 34,977	$ (77,023)	$ 183,750	$91,921	$ 14,898
15	10	-6300	12000	$ 37,617	$ (74,383)	$ 187,500	$86,849	$ 12,466
16	11	-6300	12000	$ 40,062	$ (71,938)	$ 191,250	$82,024	$ 10,086
17	12	-7300	12000	$ 41,928	$ (70,072)	$ 195,000	$77,437	$ 7,366
18	13	-6300	12000	$ 44,024	$ (67,976)	$ 198,750	$73,080	$ 5,104
19	14	-6300	12000	$ 45,965	$ (66,035)	$ 202,500	$68,943	$ 2,908
20	15	-6300	12000	$ 47,762	$ (64,238)	**$ 206,250**	$65,019	**$ 780**
21	16	-6300	12000	$ 49,426	$ (62,574)	**$ 210,000**	$61,297	**$ (1,277)**
22	17	-6300	12000	$ 50,966	$ (61,034)	$ 213,750	$57,770	$ (3,264)
23	18	-7300	12000	$ 52,142	$ (59,858)	$ 217,500	$54,429	$ (5,429)
24	19	-6300	12000	$ 53,463	$ (58,537)	$ 221,250	$51,266	$ (7,271)
25	20	-6300	12000	$ 54,686	$ (57,314)	$ 225,000	$48,273	$ (9,041)

Breakeven occurs here

=$E25+ $G25

= NPV($D$1,$B$6:$B25)
+ NPV($D$1,$C$6:$C25)

=$D25 + $B$5

=2500*(60+1.5*$A25)

=-PV($D$1,$A25,,$F25)

Sheet1 Sheet2 Sheet3

13.24 Let x = number of samples per year. Set AW values for complete and partial labs equal to the complete outsource cost.

(a) Complete lab option

$$-50{,}000(A/P,10\%,6) - 26{,}000 - 10x = -120x$$
$$-50{,}000(0.22961) - 26{,}000 = -110x$$

$$x = 341 \text{ samples per year}$$

(b) Partial lab option

$$-35{,}000(A/P,10\%,6) - 10{,}000 - 3x - 40x = -120x$$
$$-35{,}000(0.22961) - 10{,}000 = -77x$$

$$x = 234 \text{ samples per year}$$

(c) Equate AW of complete and partial labs

$$-50{,}000(A/P,10\%,6)-26{,}000 -10x = -35{,}000(A/P,10\%,6) -10{,}000 -3x - 40x$$
$$-50{,}000(0.22961) - 26{,}000 - 10x = -35{,}000(0.22961) - 10{,}000 - 43x$$
$$33x = 19{,}444$$

$$x = 589 \text{ samples per year}$$

Ranges for the lowest total cost are:

$0 < x \le 234$	select outsource
$234 < x \le 589$	select partial lab
$589 < x$	select complete lab

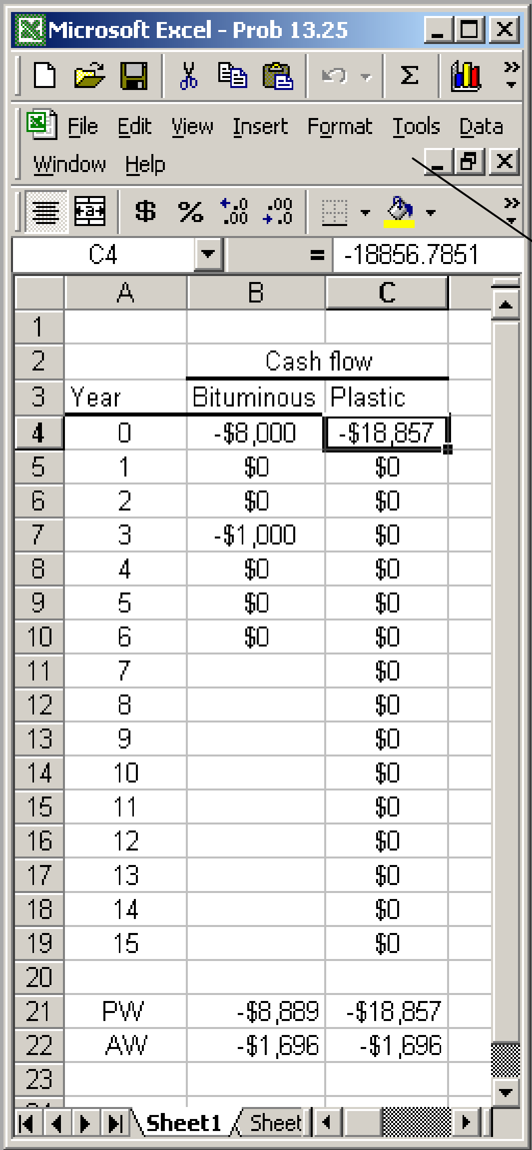
(d) At 300 samples per year, the partial lab option is the best economically at TC = $30,936.

13.25 Let P = initial cost of plastic lining. Use AW analysis.

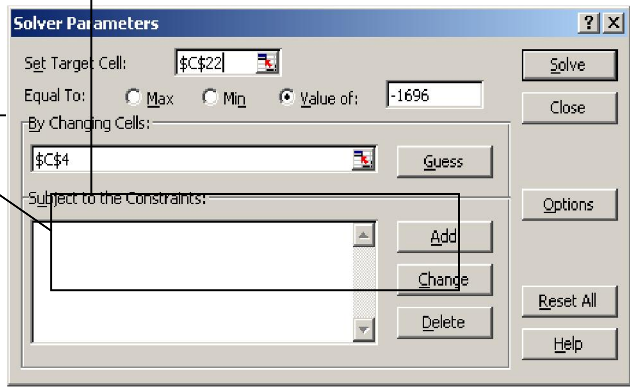
(a) by hand:

$$-8{,}000(A/P,4\ \%,6) - 1000(P/F,4\ \%,3)(A/P,4\ \%,6) = -P(A/P,4\ \%,15)$$
$$-8{,}000(0.19076) - 1000(0.8890)(0.19076) = -P(0.08994)$$
$$-1695.66 = -P(0.08994)$$
$$P = \$18{,}853$$

(b) by computer: Enter cash flows and set SOLVER to find the initial cost of plastic liner alternative (Cell C4 here).



	A	B	C
1			
2		Cash flow	
3	Year	Bituminous	Plastic
4	0	-$8,000	-$18,857
5	1	$0	$0
6	2	$0	$0
7	3	-$1,000	$0
8	4	$0	$0
9	5	$0	$0
10	6	$0	$0
11	7		$0
12	8		$0
13	9		$0
14	10		$0
15	11		$0
16	12		$0
17	13		$0
18	14		$0
19	15		$0
20			
21	PW	-$8,889	-$18,857
22	AW	-$1,696	-$1,696
23			



Changing cell to make the AW values equal

13.26 (a) By hand: Let P = first cost of sandblasting. Equate the PW of painting each 4 years to PW of sandblasting each 10 years, up to a total of 38 years for each option.

<u>PW of painting</u>

PW_p = -2,800 - 3,360(P/F,10%,4) - 4,032(P/F,10%,8) - 4,838(P/F,10%12) – 5,806(P/F,10%,16) - 6,967(P/F,10%,20) -8,361(P/F,10%,24) – 10,033(P/F,10%,28) - 12,039(P/F,10%,32) -14,447(P/F,10%,36)

= -2,800 - 3,360(0.6830) - 4,032(0.4665) - 4,838(0.3186) -5,806(0.2176) - 6,967(0.1486) - 8,361(0.1015) - 10,033(0.0693) -12,039(0.0474) - 14,447(0.0323)

= $-13,397

PW of sandblasting

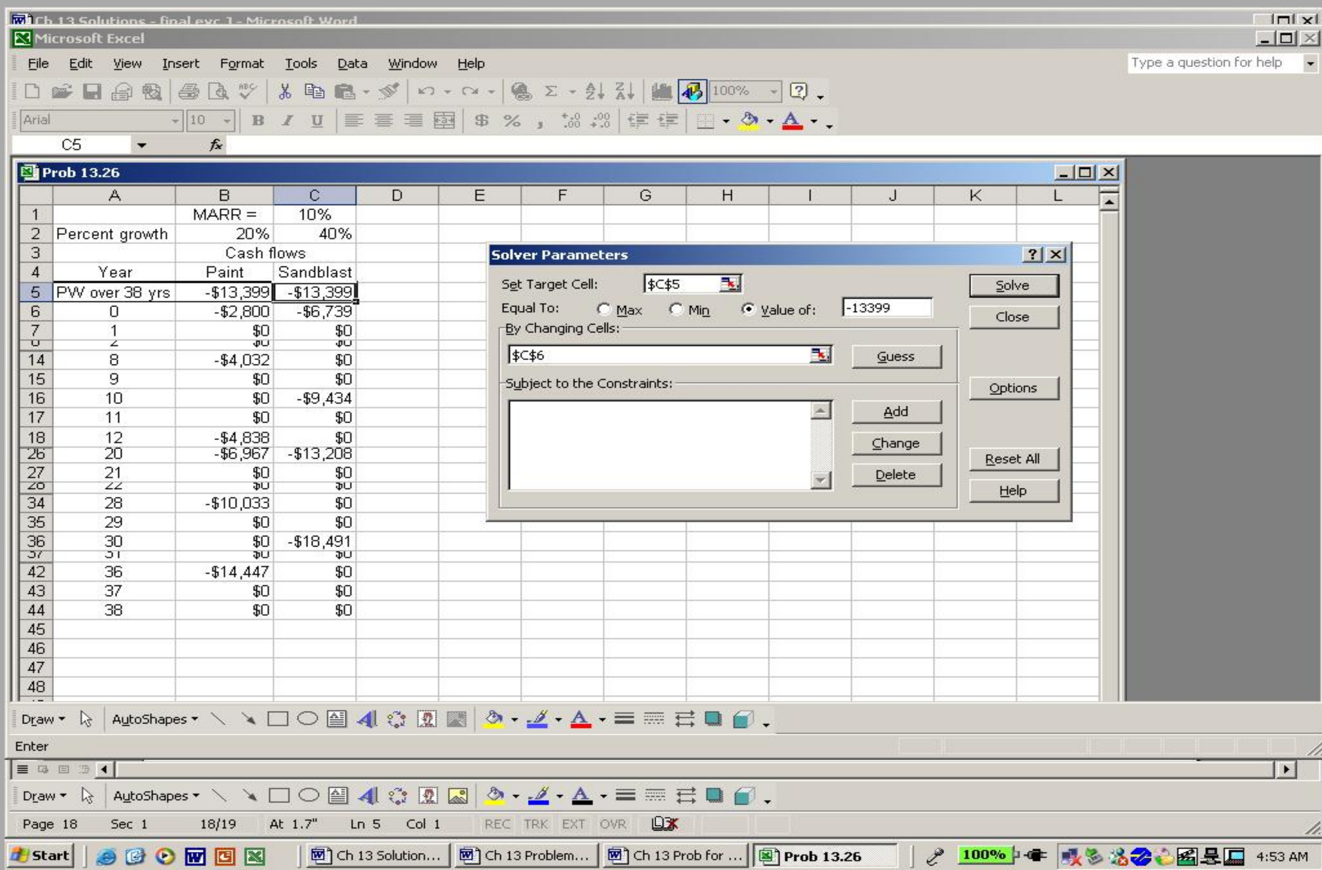
$$PW_s = -P - 1.4P(P/F,10\%,10) - 1.96P(P/F,10\%,20) - 2.74P(P/F,10\%,30)$$
$$-P[1 + 1.4(0.3855) + 1.96(0.1486) + 2.74(0.0573)]$$
$$= -1.988P$$

Equate the PW relations.

$$-13{,}397 = -1.988P$$
$$P = \$6{,}739$$

(b) By computer: Enter the periodic costs. Enter 0 for the P of the sandblasting option. Use SOLVER to find breakeven at P = -$6739 (cell C6). (Note that many of the year entries are hidden in the Excel image below.)

13.26 (b) (cont)



	A	B	C
1		MARR =	10%
2	Percent growth	20%	40%
3		Cash flows	
4	Year	Paint	Sandblast
5	PW over 38 yrs	-$13,399	-$13,399
6	0	-$2,800	-$6,739
7	1	$0	$0
14	8	-$4,032	$0
15	9	$0	$0
16	10	$0	-$9,434
17	11	$0	$0
18	12	-$4,838	$0
26	20	-$6,967	-$13,208
27	21	$0	$0
34	28	-$10,033	$0
35	29	$0	$0
36	30	$0	-$18,491
42	36	-$14,447	$0
43	37	$0	$0
44	38	$0	$0

(c) Change cell C2 to 30% and then 20% and re-SOLVER to get:

30%: P = -$7133 20%: P = -$7546

Case Study Solution

1. Savings = 40 hp * 0.75 kw/hp * 0.06 $/kwh * 24 hr/day * 30.5 days/mo ÷ 0.90
   = $1464/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 4¢/kwh, the aeration and sludge recirculation monthly costs would be $976 and $122, respectively. The net savings for alternative 2 would then be $-1727, for alternative 3 would be $-131, and for alternative four -$751---all losses. Therefore, the best alternative would be number 1, continuation of the normal operating condition.

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) $$1{,}849/30.5 = (5)(0.75)(x)(24)/0.90 + (40)(0.75)(x)(24)/0.90$$
$$x = 6.7 \text{ cents per kwh}$$

Chapter 14
Effects of Inflation

Solutions to Problems

14.1 Inflated dollars are converted into constant value dollars by dividing by one plus the inflation rate per period for however many periods are involved.

14.2 Something will double in cost in 10 years when the value of the money has decreased by exactly one half. Thus:

$$(1 + f)^{10} = 2$$
$$(1 + f) = 2^{0.1}$$
$$= 1.0718$$
$$f = 7.2\% \text{ per year}$$

14.3 (a) Cost in then-current dollars $= 106{,}000(1 + 0.03)^2$
$= \$112{,}455$

(b) Cost in today's dollars = \$106,000

14.4 Then-current dollars $= 10{,}000(1 + 0.07)^{10}$
$= \$19{,}672$

14.5 Let CV = current value
$CV_0 = 10{,}000/(1 + 0.07)^{10}$
$= \$5083.49$

14.6 Find inflation rate and then convert dollars to CV dollars:

$$0.03 + f + 0.03(f) = 0.12$$
$$1.03f = 0.09$$
$$f = 8.74\%$$

$CV_0 = 10{,}000/(1 + 0.0874)^{10}$
$= \$4326.20$

14.7 CV_0 for amt in yr 1 $= 13{,}000/(1 + 0.06)^1$
$= \$12{,}264$

CV_0 for amt in yr 2 $= 13{,}000/(1 + 0.06)^2$
$= \$11{,}570$

CV_0 for amt in yr 3 $= 13{,}000/(1 + 0.06)^3$
$= \$10{,}915$

14.8 Number of future dollars = $2000(1 + 0.05)^5$
$= \$2552.56$

14.9 Cost = $21{,}000(1 + 0.028)^2 = \$22{,}192$

14.10 (a) At a 56% increase, \$1 would increase to \$1.56. Let x = annual increase.

$$1.56 = (1 + x)^5$$
$$1.56^{0.2} = 1 + x$$
$$1.093 = 1 + x$$
$$x = 9.3\% \text{ per year}$$

(b) Amount greater than inflation rate: 9.3 – 2.5 = 6.8% per year

14.11 $55{,}000 = 45{,}000(1 + f)^4$
$(1 + f) = 1.222^{0.25}$
$f = 5.1\%$ per year

14.12 (a) The market interest rate is higher than the real rate during periods of inflation
(b) The market interest rate is lower than the real rate during periods of deflation
(c) The market interest rate is the same as the real rate when inflation is zero

14.13 $i_f = 0.04 + 0.27 + (0.04)(0.27)$
$= 32.08\%$ per year

14.14 $0.15 = 0.04 + f + (0.04)(f)$
$1.04f = 0.11$
$f = 10.58\%$ per year

14.15 i_f per quarter $= 0.02 + 0.05 + (0.02)(0.05)$
$= 7.1\%$ per quarter

14.16 For this problem, $i_f = 4\%$ per month and $i = 0.5\%$ per month

$$0.04 = 0.005 + f + (0.005)(f)$$
$$1.005f = 0.035$$
$$f = 3.48\% \text{ per month}$$

14.17 $0.25 = i + 0.10 + (i)(0.10)$
$1.10i = 0.15$
$i = 13.6\%$ per year

14.18 Market rate per 6 months = 0.22/2 = 11%
$0.11 = i + 0.07 + (i)(0.07)$
$1.07i = 0.04$
$i = 3.74\%$ per six months

14.19 Buying power = $1{,}000{,}000/(1 + 0.03)^{27}$
$= \$450{,}189$

14.20 (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

14.21 Find present worth of all three plans:
Method 1: $PW_1 = \$400{,}000$
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: $PW_3 = 750{,}000(P/F,10\%,5)$
$= \$750{,}000(0.6209)$
$= \$465{,}675$

Select payment method 2

14.22 (a) $PW_A = -31{,}000 – 28{,}000(P/A,10\%,5) + 5000(P/F,10\%,5)$
$= -31{,}000 – 28{,}000(3.7908) + 5000(0.6209)$
$= \$-134{,}038$

$PW_B = -48{,}000 – 19{,}000(P/A,10\%,5) + 7000(P/F,10\%,5)$
$= -48{,}000 – 19{,}000(3.7908) + 7000(0.6209)$
$= \$-115{,}679$

Select Machine B

(b) $i_f = 0.10 + 0.03 + (0.10)(0.03) = 13.3\%$
$PW_A = -31{,}000 – 28{,}000(P/A,13.3\%,5) + 5000(P/F,13.3\%,5)$
$= -31{,}000 – 28{,}000(3.4916) + 5000(0.5356)$
$= \$-126{,}087$

$$
\begin{aligned}
PW_B &= -48{,}000 - 19{,}000(P/A,13.3\%,5) + 7000(P/F,13.3\%,5) \\
&= -48{,}000 - 19{,}000(3.4916) + 7000(0.5356) \\
&= \$-110{,}591
\end{aligned}
$$

Select machine B

14.23 $i_f = 0.12 + 0.03 + (0.12)(0.03) = 15.36\%$

$$
\begin{aligned}
CC_X &= -18{,}500{,}000 - 25{,}000/0.1536 \\
&= \$-18{,}662{,}760
\end{aligned}
$$

For alternative Y, first find AW and then divide by i_f

$$
\begin{aligned}
AW_Y &= -9{,}000{,}000(A/P,15.36\%,10) - 10{,}000 + 82{,}000(A/F,15.36\%,10) \\
&= -9{,}000{,}000(0.20199) - 10{,}000 + 82{,}000(0.0484) \\
&= \$-1{,}823{,}971
\end{aligned}
$$

$$
\begin{aligned}
CC_Y &= 1{,}823{,}971/0.1536 \\
&= \$-11{,}874{,}811
\end{aligned}
$$

Select alternative Y

14.24 Use the inflated rate of return for Salesman A and real rate of return for B

$i_f = 0.15 + 0.05 + (0.15)(0.05) = 20.75\%$

$$
\begin{aligned}
PW_A &= -60{,}000 - 55{,}000(P/A,20.75\%,10) \\
&= -60{,}000 - 55{,}000(4.0880) \\
&= \$-284{,}840
\end{aligned}
$$

$$
\begin{aligned}
PW_B &= -95{,}000 - 35{,}000(P/A,15\%,10) \\
&= -95{,}000 - 35{,}000(5.0188) \\
&= \$-270{,}658
\end{aligned}
$$

Recommend purchase from salesman B

14.25 (a) New yield = 2.16 + 3.02
= 5.18% per year

(b) Interest received = 25,000(0.0518/12)
= $107.92

14.26 (a) $F = 10{,}000(F/P,10\%,5)$
$= 10{,}000(1.6105)$
$= \$16{,}105$

(b) Buying Power $= 16{,}105/(1 + 0.05)^5$
$= \$12{,}619$

(c) $i_f = i + 0.05 + (i)(0.05)$
$0.10 = i + 0.05 + (i)(0.05)$
$1.05i = 0.05$
$i = 4.76\%$

or use Equation [14.9]

$i = (0.10 – 0.05)/(1 + 0.05)$
$= 4.76\%$

14.27 (a) Cost $= 45{,}000(F/P,3.7\%,3)$
$= 45{,}000(1.1152)$
$= \$50{,}184$

(b) $P = 50{,}184(P/F,8\%,3)$
$= 50{,}184(0.7938)$
$= \$39{,}836$

14.28 $740{,}000 = 625{,}000(F/P,f,7)$
$(F/P,f,7) = 1.184$
$(1 + f)^7 = 1.184$
$f = 2.44\%$ per year

14.29 Buying power $= 1{,}500{,}000/(1 + 0.038)^{25}$
$= \$590{,}415$

14.30 $i_f = 0.15 + 0.04 + (0.15)(0.04) = 19.6\%$

PW of buying now is \$80,000

PW of buying later $= 128{,}000(P/F,19.6\%,3)$
$= 128{,}000(0.5845)$
$= \$74{,}816$

Buy 3-years from now

14.31 In constant-value dollars, cost will be \$40,000.

14.32 In *constant-value dollars*

$$\begin{aligned}\text{Cost} &= 40{,}000(F/P,5\%,3)\\ &= 40{,}000(1.1576)\\ &= \$46{,}304\end{aligned}$$

14.33 In then-current dollars for f = - 1.5%

$$\begin{aligned}F &= 100{,}000(1 - 0.015)^{10}\\ &= 100{,}000(0.85973)\\ &= \$85{,}973\end{aligned}$$

14.34 Future amount is equal to a return of i_f on its investment

$$i_f = (0.10 + 0.04) + 0.03 + (0.1 + 0.04)(0.03) = 17.42\%$$

$$\begin{aligned}\text{Required future amt} &= 1{,}000{,}000(F/P,17.42\%,4)\\ &= 1{,}000{,}000(1.9009)\\ &= \$1{,}900{,}900\end{aligned}$$

Company will get more; make the investment

14.35 (a) $653{,}000 = 150{,}000(F/P,f,95)$

$$\begin{aligned}4.3533 &= (1 + f)^{95}\\ f &= 1.56\% \text{ per year}\end{aligned}$$

(b) Total of 14 years will pass.

$$\begin{aligned}F &= 653{,}000(1 + 0.035)^{14}\\ &= 653{,}000(1.6187)\\ &= \$1{,}057{,}011\end{aligned}$$

14.36

$$\begin{aligned}F &= P[(1 + i)(1 + f)(1 + g)]^n\\ &= 250{,}000[(1 + 0.05)(1 + 0.03)(1 + 0.02)]^5\\ &= 250{,}000(1.6336)\\ &= \$408{,}400\end{aligned}$$

14.37 $i_f = 0.15 + 0.06 + (0.15)(0.06) = 21.9\%$

$$\begin{aligned}AW &= 183{,}000(A/P,21.9\%,5)\\ &= 183{,}000(0.34846)\\ &= \$63{,}768\end{aligned}$$

14.38 (a) In constant value dollars, use i = 12% to recover the investment

$$AW = 40{,}000{,}000(A/P,12\%,10)$$
$$= 40{,}000{,}000(0.17698)$$
$$= \$7{,}079{,}200$$

(b) In future dollars, use i_f to recover the investment

$$i_f = 0.12 + 0.07 + (0.12)(0.07) = 19.84\%$$

$$AW = 40{,}000{,}000(A/P,19.84\%,10)$$
$$= 40{,}000{,}000(0.23723)$$
$$= \$9{,}489{,}200$$

14.39 Use market interest rate (i_f) to calculate AW in then-current dollars

$$AW = 750{,}000(A/P,10\%,5)$$
$$= 750{,}000(0.26380)$$
$$= \$197{,}850$$

14.40 Find amount needed at 2% inflation rate and then find A using market rate.

$$F = 15{,}000(1 + 0.02)^3$$
$$= 15{,}000(1.06121)$$
$$= \$15{,}918$$

$$A = 15{,}918(A/F,8\%,3)$$
$$= 15{,}918(0.30803)$$
$$= \$4903$$

14.41 (a) Use *f* rate to maintain purchasing power, then find A using market rate.

$$F = 5{,}000{,}000(F/P,5\%,4)$$
$$= 5{,}000{,}000(1.2155)$$
$$= \$6{,}077{,}500$$

(b) $A = 6{,}077{,}500(A/F,10\%,4)$
$$= 6{,}077{,}500(0.21547)$$
$$= \$1{,}309{,}519$$

14.42 (a) Use i_f (market interest rate) to find AW.

$$AW = 50{,}000(0.08) + 5000 = \$9000$$

(b) For CV dollars, first find P using i (real interest rate); then find A using i_f

14.43 (a) For CV dollars, use i = 12% per year

$$AW_A = -150{,}000(A/P,12\%,5) - 70{,}000 + 40{,}000(A/F,12\%,5)$$
$$= -150{,}000(0.27741) - 70{,}000 + 40{,}000(0.15741)$$
$$= \$-105{,}315$$

$$AW_B = -1{,}025{,}000(0.12) - 5{,}000$$
$$= \$-128{,}000$$

Select Machine A

(b) For then-current dollars, use i_f

$$i_f = 0.12 + 0.07 + (0.12)(0.07) = 19.84\%$$

$$AW_A = -150{,}000(A/P,19.84\%,5) - 70{,}000 + 40{,}000(A/F,19.84\%,5)$$
$$= -150{,}000(0.3332) - 70{,}000 + 40{,}000(0.1348)$$
$$= \$-114{,}588$$

$$AW_B = -1{,}025{,}000(0.1984) - 5{,}000$$
$$= \$-208{,}360$$

Select Machine A

FE Review Solutions

14.44 $i_f = 0.12 + 0.07 + (0.12)(0.07) = 19.84\%$

Answer is (d)

14.45 Answer is (c)

14.46 Answer is (d)

14.47 Answer is (b)

14.48 Answer is (c)

14.49 Answer is (a)

Extended Exercise Solution

1. Find overall i* = 5.90%.

2. $i_f = 11.28\%$
   $F = 25{,}000(F/P,11.28\%,3) - 1475(F/A,11.28\%,3)$

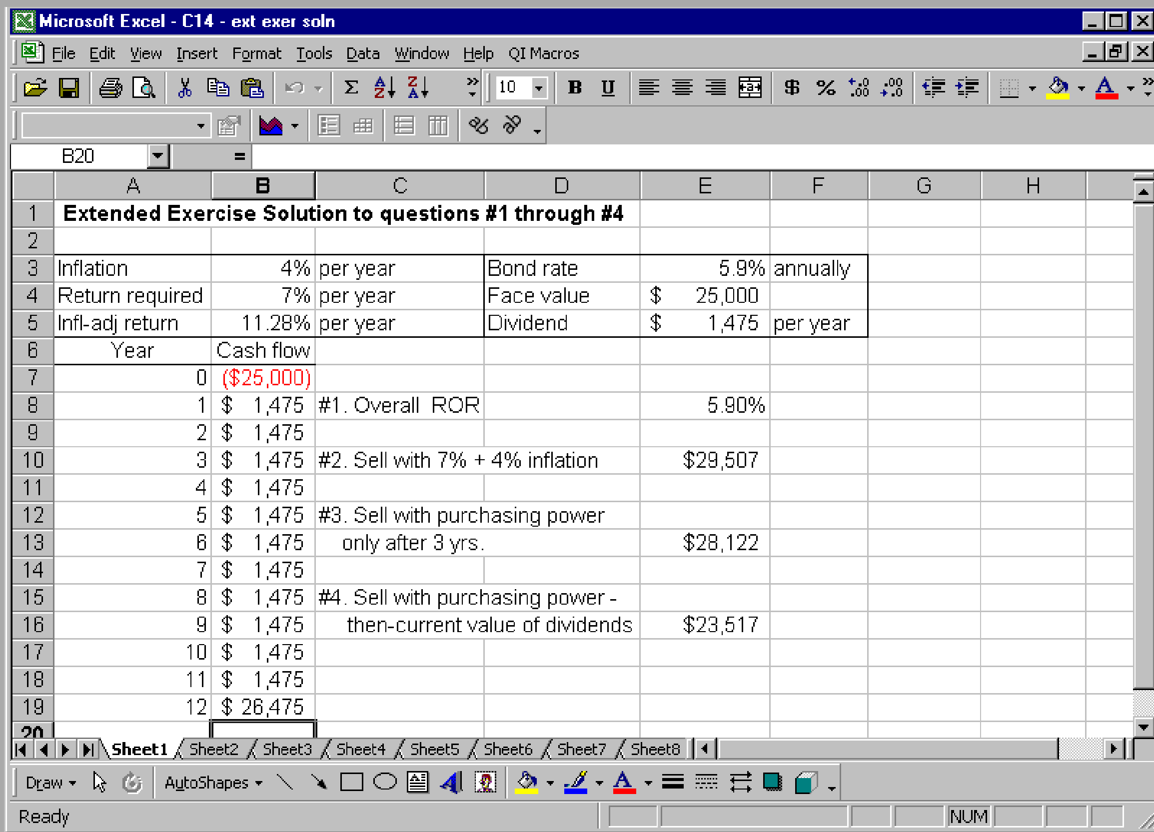
3. $F = 25{,}000(F/P,4\%,3)$

4. Subtract the future value of each payment from the bond face value 3 years from now. Both amounts take purchasing power into account.

   $$F = 25{,}000(F/P,4\%,3) - 1475[(1.04)^2 + (1.04) + 1] = \$23{,}517$$

   In Excel, this can be written as:

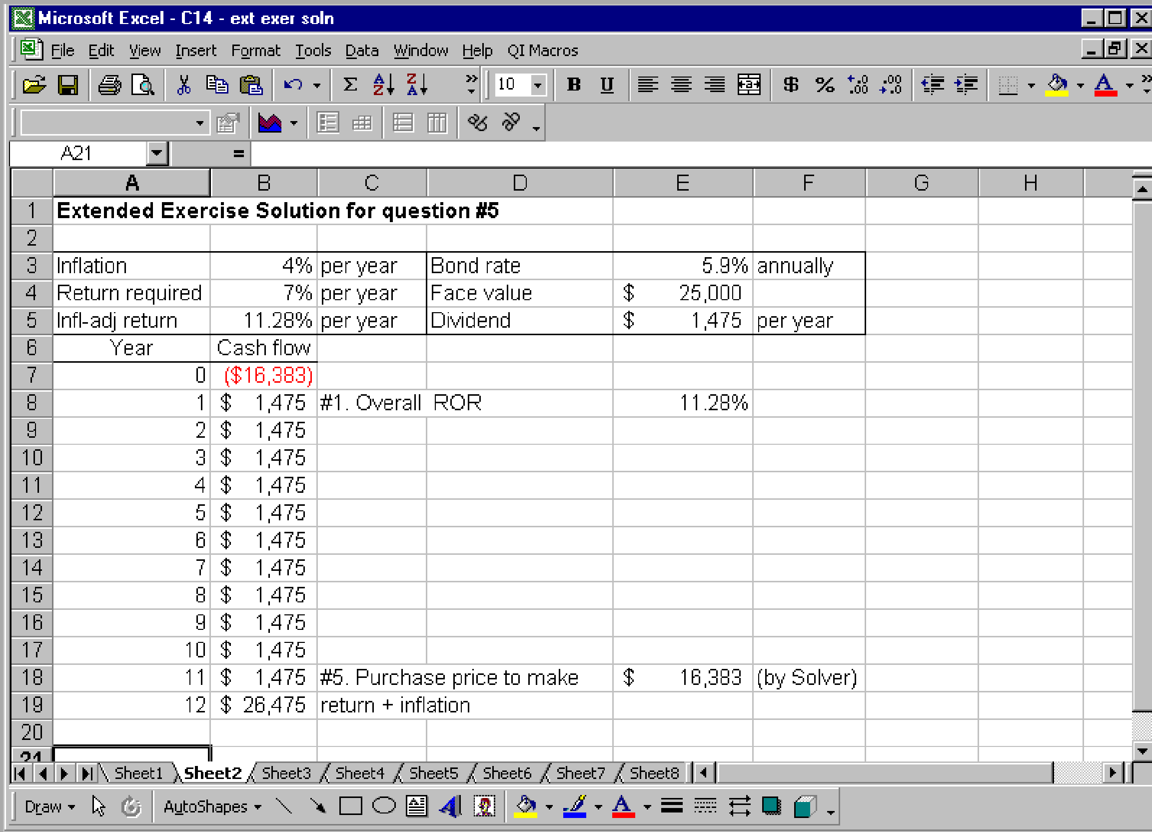
   FV(4%,3,1475,–25000) = $23,517

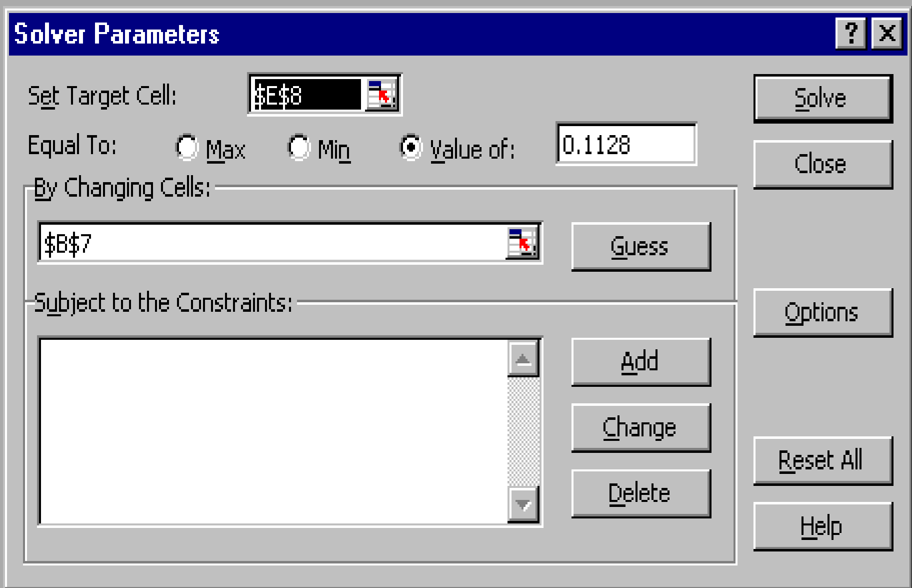


Microsoft Excel - C14 - ext exer soln

	A	B	C	D	E	F
1	Extended Exercise Solution to questions #1 through #4					
2						
3	Inflation	4%	per year	Bond rate	5.9%	annually
4	Return required	7%	per year	Face value	$ 25,000	
5	Infl-adj return	11.28%	per year	Dividend	$ 1,475	per year
6	Year	Cash flow				
7	0	($25,000)				
8	1	$ 1,475	#1. Overall ROR		5.90%	
9	2	$ 1,475				
10	3	$ 1,475	#2. Sell with 7% + 4% inflation		$29,507	
11	4	$ 1,475				
12	5	$ 1,475	#3. Sell with purchasing power			
13	6	$ 1,475	only after 3 yrs.		$28,122	
14	7	$ 1,475				
15	8	$ 1,475	#4. Sell with purchasing power -			
16	9	$ 1,475	then-current value of dividends		$23,517	
17	10	$ 1,475				
18	11	$ 1,475				
19	12	$ 26,475				

5. Use SOLVER to find the purchase price (B7) at 11.28% (E8).





Chapter 15

Cost Estimation and Indirect Cost Allocation

Solutions to Problems

15.1 (a) Equipment cost, delivery charges, installation cost, insurance, and training.
(b) Labor, materials, maintenance, power.

15.2 The main difference is what is considered an input variable and an output variable. The bottom-up approach uses price as output and cost estimates as inputs. The design-to-cost approach is just the opposite.

15.3 (a) Direct; (b) Indirect, since it is usually an option to choose a non-toll route; (c) Direct; (d) Indirect; (e) Direct, since it is a part of the direct cost of gas; (f) Direct, but could be considered indirect it is assumed that the owner can drive for a while without paying the monthly loan bill, prior to repossession.

15.4 Property cost: (100 X 150)(2.50) = \$37,500
House cost: (50 X 46)(.75)(125) = \$215,625
Furnishings: (6)(3,000) = \$18,000

Total cost: \$271,125

15.5 A: \$120(130,000) = \$15.60 million

B:

Type	Area	Unit cost	Estimated cost
Classroom	39,000	\$125	\$4.8750 million
Lab	52,000	185	9.6200 million
Office	39,000	110	4.2900 million
Furnishings-labs	32,500	150	4.8750 million
Furnishings-other	97,500	25	2.4375 million
			\$26.0975 million

Average unit cost estimate from A is \$15,600,000, which is only about half using the more detailed breakout cost by function of \$26,097,500 estimate from B.

15.6 $$\text{Cost} = \frac{1200}{1027.5}(78,000)$$
$$= \$91,095$$

15.7 (Note: This answer uses a mid-year 2004 ENR index value of 7064. The current value must be obtained from the web to get the current estimate at the time the problem is assigned.

Cost = (7064/5471)(2.3 million) = $2.970 million

15.8 From the website, it can be determined that they differ primarily in the basis of the labor component of the standard cost. The CCI uses a total of 200 hours of common labor multiplied by the 20-city average rate for wages and fringe benefits. The BCI uses a total of 66.38 hours of skilled labor, multiplied by the 20-city average rate for wages and fringes for three trade areas –bricklayers, carpenters and structural ironworkers.

The two indexes apply to general construction costs. The CCI can be used where labor costs are a high proportion of total costs. The BCI is more applicable for structures.

15.9 $30{,}000 = \frac{x}{915.1}(20{,}000)$

$x = 1372.7$

15.10 (a) First find the percentage increase (p%) between 1990 and 2000.

$6221 = 4732\ (F/P,p,10)$

$1.31467 = (1+p)^{10}$

p% increase = 2.773 %/year

Predicted index value in 2002 = 6221(F/P,2.773%,2)

$= 6221(1+0.02773)^2$

$= 6571$

(b) Difference = 6571 – 6538

= 33 (too high)

15.11 $1{,}600{,}000 = \frac{1315}{720}(x)$

$x = \$876{,}046$

15.12 Cost in mid-2004 = 325,000 (7064/4732)

= $485,165

15.13 Find the percentage increase (p%) between 1994 and 2002 of the index. The other numbers are not needed.

$395.6 = 368.1(F/P,p,8)$

$1.0747 = (1+p)^{1/8}$

$(1+p) = 1.009046$
p % increase = 0.905 % per year

15.14 (a) Divide 2002 value by the 1990 base value of 357.6 and multiply by 100.

$$2002 \text{ value} = (395.6/357.6)(100) = 110.6$$

(b) For example, in mid-2004, www.che.com/pindex provides the index value of 434.6. The month's index estimate is:

$$2004 \text{ estimate} = (434.6/357.6)(100) = 121.5$$

15.15 $395.6 = 357.6(F/P,p\%,12)$
$1.10626 = (1+p\%)^{12}$
$(1+p) = 1.00845$
p% increase = 0.845 % per year

15.16 Index in 2005 $= 1068.3(F/P,2\%,6)$
$= 1068.3(1+0.02)^6$
$= 1203.1$

15.17 (a) Cost $= 60{,}000\ (1+0.02)^3\ (1+0.05)^7$
$= \$89{,}594$

(b) $89{,}594 = 60{,}000(I_{10}/1203)$
$I_{10} = 1796.36$

15.18 The cost index bases the estimate on cost differences over time for a *specified value* of variables, while a CER estimates costs between *different values* of design variables.

15.19 From Table 15-3, the cost-capacity exponent is 0.32.

$C_2 = 13{,}000(450/250)^{0.32}$
$= 13{,}000(1.207)$
$= \$15{,}690$

15.20 Correlating exponent is 0.69 for all pump ratings.

(a) Use Equation [15.2] for 200 hp

$C_2 = 20{,}000(200/100)^{0.69}$
$= 20{,}000(1.613) = \$32{,}260$

For 75 hp

$$C_2 = 20{,}000(75/100)^{0.69}$$
$$= 20{,}000(0.82) = \$16{,}400$$

A 200-hp pump is estimated to cost about twice as much as a 75-hp one.

(b) Use Equation [15.3] with a cost index ratio of 1.2.

$$C_2 = 20{,}000(200/100)^{0.69}(1.20)$$
$$= 20{,}000(1.613)(1.2) = \$38{,}712$$

15.21 $3{,}000{,}000 = 550{,}000\ (100{,}000/6000)^x$

$5.4545 = (16.6667)^x$

$\log 5.4545 = x \log 16.667$

$0.7367 = 1.2218\ x$

$x = 0.60$

15.22 (a) $450{,}000 = 200{,}000(60{,}000/35{,}000)^x$

$2.25 = 1.7143^x$

$\log 2.25 = 0.3522 = x \log 1.7143 = 0.2341$

$x = 1.504$

(b) Since $x > 1.0$, there is diseconomy of scale and the larger CFM capacity is more expensive than a linear relation would be.

15.23 $250 = 55(600/Q_1)^{0.67}$

$4.5454 = (600/Q_1)^{0.67}$

$Q_1 = 63$ MW

15.24 1.5 million = 0.2 million $(Q_2/1)^{0.80}$

$Q_2 = 12.4$ MGD

15.25 (a) Estimate made in 2002 using Equation [15.3]

$C_2 = (1 \text{ million})(3)^{0.2}(1.1)$

$= (1 \text{ million})(1.246)(1.1) = \$1.37$ million

Estimate was \$630,000 low

(b) Again, use Equation [15.3] to find x.

2 million = $(1 \text{ million})(3)^x(1.25)$

$1.6 = (3)^x$

$\log 1.6 = x \log 3$
$0.2041 = x\ (0.4771)$
$x = 0.428$

15.26 Use Equation [15.3] and Table 15-2.
$C_2 = 50{,}000\ (2/1)^{0.24}\ (395.6/389.5)$
$= 50{,}000\ (1.181)(1.0157)$
$= \$59{,}974$

15.27 C_2 in 1995 $= 160{,}000\ (1000/200)^{0.35}$
$= \$281{,}034$

C_2 in 2002 $= 281{,}034\ (1.35)$
$= \$379{,}396$

15.28 *ENR* construction cost index ratio is (6538/4732).
Cost -capacity exponent is 0.60.

Let C_1 = cost of 5,000 sq. m. structure in 1990

C_2 in 1990 $= \$220{,}000 = C_1\ (10{,}000/5{,}000)^{0.60}$
$C_1 = \$145{,}145$

Update C_1 with cost index. To update to 2002

$C_{2002} = C_1\ (6538/4732)$
$= 145{,}145\ (1.382)$
$= \$200{,}540$

15.29 $C_T = 2.97\ (16)$
$= \$47.5$ million

15.30 (a) $h = 1 + 1.52 + 0.31 = 2.83$

$C_T = 2.83\ (1{,}600{,}000)$
$= \$4{,}528{,}000$

(b) $h = 1 + 1.52 = 2.52$
$C_T = [1{,}600{,}000(2.52)](1.31)$
$= \$5{,}281{,}920$

15.31 $h = 1 + 0.2 + 0.5 + 0.25 = 1.95$

Apply Equation [15.5]

C_T in 1994: 1.75 (1.95) = \$3.41 million

Update with the cost index to now.

C_T now: 3.41 (3713/2509) = 3.41(1.48) = \$5.05 million

15.32 (a) $h = 1 + 0.30 + 0.30 = 1.60$

Let x be the indirect cost factor.

$$
\begin{aligned}
C_T = 450{,}000 &= [250{,}000\ (1.60)]\ (1 + x) \\
(1 + x) &= 450{,}000/[250{,}000\ (1.60)] \\
&= 1.125 \\
x &= 0.125
\end{aligned}
$$

The indirect cost factor used is much lower than 0.40.

(b) $C_T = 250{,}000[1.60](1.40)$
$= \$560{,}000$

15.33 (a) Humboldt plant: Apply Equation [15.7] for each machining type and quarter for 4 different rates. A total of \$225,000 is allocated to each type of machinery. Calculations are performed in \$1,000/1,000 DL hour.

Q1 rate		Q2 rate	
Heavy	Light	Heavy	Light
225/2 = \$112.50/hr	225/0.8 = \$281.25/hr	225/1.5 = \$150/hr	225/1.5 = \$150/hr

(b) Humboldt plant: Blanket rate equation to use is

$$\text{Indirect cost rate} = \frac{\text{total indirect costs for Q1}}{\text{total direct labor hours for Q1}}$$

Blanket rate for Q1 = 450/2.8 = \$160.71/DL hour

Actual charge in Q1 for light using blanket rate: (160.71)(800) = \$128,568

Actual charge in Q1 for light using light rate: (281.25)(800) = $225,000

Blanket rate under-charges light machining by the difference or $96,432

(c) Concourse plant: Use the blanket rate equation above for each quarter.

Q1 rate	Q2 rate
450/1.8 = $250/hr	450/2.8 = $160.71/hr

15.34 Indirect cost rate for 1 = $\frac{50,000}{600}$ = $ 83.33 per hour

Indirect cost rate for 2 = $\frac{100,000}{200}$ = $500.00 per hour

Indirect cost rate for 3 = $\frac{150,000}{800}$ = $187.50 per hour

Indirect cost rate for 4 = $\frac{200,000}{1,200}$ = $166.67 per hour

15.35 (a) From Eq. [15.7]

Basis level = (indirect costs allocated)/(indirect cost rate)

Month	Basis Level	Basis
June	20,000/1.50 = 13,333	DL hours
July	34,000/1.33 = 25,564	DL costs
August	35,000/1.37 = 25,547	DL costs
September	36,000/1.25 = 28,800	Space
October	36,250/1.25 = 29,000	Space

(b) The indirect cost rate has decreased and is constant due to the switching of the allocation basis from one month to the next. If a single allocation basis is used throughout, the monthly rate are significantly different than those indicated. For example, if space is consistently used as the basis, monthly rates are:

June $\frac{20,000}{20,000}$ = $1.00 per ft^2

July $\frac{34,000}{20,000}$ = $1.70 per ft^2

August $\frac{35,000}{29,000}$ = $1.21 per ft^2

September $\frac{36,000}{29,000}$ = $1.24 per ft^2

October $\frac{36,250}{29,000}$ = $1.25 per ft^2

15.36 (a) Space: Use Equation [15.7] for the rate, then allocate the $34,000.

Total space in 3 depts = 38,000 ft^2

Rate = 34,000/38,000 = $0.89 per ft^2

(b) Direct labor hours:

Total hours = 2,080

Rate = 34,000/2,080 = $16.35 per hour

(c) Direct labor cost:

Total costs = $147,390

Rate = 34,000/147,390 = $0.23 per $

15.37 Housing: DLH is basis; rate is $16.35

Actual charge = 16.35(480) = $7,848

Subassemblies: DLH is basis; rate is $16.35

Actual charge = 16.35(1,000) = $16,350

Final assembly: DLC is basis; rate is $0.23

Actual charge = 0.23 (12,460) = $2,866

15.38 (a) Actual charge = (rate)(actual machine hours) where the rate value is from 15.34.

Cost center	Rate	Actual hours	Actual charge	Allocation	Allocation variance
1	$83.33	700	$58,331	$ 50,000	$8,331 under
2	500.00	350	175,000	100,000	75,000 under
3	187.50	650	121,875	150,000	28,125 over
4	166.67	1,400	233,338	200,000	33,338 under
			$588,544	$500,000	

(b) Total variance = allocation – actual charges

= 500,000 – 588,544

= $– 88,544 (under-allocation)

15.39 (a) Indirect cost charge = (allocation rate) (basis level)

Department 1: 2.50(5,000) = $ 12,500

Department 2: 0.95(25,000) = 23,750

Department 3: 1.25(44,100) = 55,125

Department 4: 5.75(84,000) = 483,000

Department 5: 3.45(54,700) = 188,715

Department 6: 0.75(19,000) = 14,250

Total actual charges = $777,340

(b) Variance = allocation – actual charges
= 800,000 – 777,340
= $ +22,660 (over-allocation)

15.40 DLC average rate = (1.25 + 5.75 + 3.45) /3 = $3.483 per DLC $

Department 1:	3.483(20,000) =	$ 69,660
Department 2:	3.483(35,000) =	121,905
Department 3:	3.483(44,100) =	153,600
Department 4:	3.483(84,000) =	292,572
Department 5:	3.483(54,700) =	190,520
Department 6:	3.483(69,000) =	240,327
Total actual charges		$1,068,584

Allocation variance = allocation – actual charges
= 800,000 – 1,068,584
= $ -268,584 (under-allocation)

15.41 (a) Alternatives are Make and Buy. Determine the total monthly costs, TC.

TC_{make} = –DLC – materials cost – indirect costs for Housing
– indirect costs from Testing and Engineering
= –31,680 – 41,000 – 20,000 – 3500
= $–96,180 per month

TC_{buy} = $–87,500 per month

Buy the components.

(b) Three alternatives are Make/old, Buy, and Make/new, meaning with new equipment.

$TC_{make/old}$ = $–96,180 per month

TC_{buy} = $–87,500 per month

$TC_{make/new}$ = –AW of equipment – DLC – materials cost
– total indirect costs for Housing and redistribution
from Testing and Engineering

The new indirect costs and direct labor hours for all departments are:

Department	Indirect cost	Direct labor hours
Housing	$20,000	200
Subassemblies	45,000	1,000
Final assembly	10,000	600
Testing	13,000	---
Engineering	16,000	---
	Total	1,800

Redistribution rate for Testing and Engineering indirect costs is based on direct labor hours:

$$\text{Redistribution rate} = \frac{\text{Testing + Engineering indirect costs}}{\text{Total direct labor hours}}$$

$$= \frac{13{,}000 + 16{,}000}{1{,}800} = \$16.11 \text{ per hour}$$

The Housing indirect cost = 200(16.11) + 20,000 = $23,222

AW of new equipment = 375,000(A/P,1%,60) + 5000
= $13,340 per month

$TC_{make/new}$ = –13,340 – 20,000 – 41,000 – 23,222
= $–97,562

Select the buy alternative.

15.42 (a) Charge = (rate)(DLH) = 4.762 (DLH)

Plant A: 4.762 (200,000) = $952,400
Plant B: $476,200
Plant C: $8,571,600

(b) Total capacity = 125,000 + 62,500 + 1,125,000 = 1,312,500

$$\text{Rate} = \frac{\$10 \text{ million}}{1.3125 \text{ million units}} = \$7.619 \text{ per unit}$$

Plant A: 7.619 (125,000) = $952,375
Plant B: $476,188
Plant C: $8,571,375

These are the same as the DLH basis.

(c)

Plant	Actual/Capacity
A	100,000/125,000 = 0.80
B	60,000/62,500 = 0.96
C	900,000/1,125,000 = 0.80

Plant A: 7.619(125,000)/0.80 = $1,190,470
Plant B: 7.619(62,500)/0.96 = $496,029
Plant C: 7.619(1,125,000)/0.80 = $10,714,219

Total allocated is $12,400,718

The first methods always allocate the exact amount of the indirect cost budget. They are based on plant parameters, not performance. The numbers in part (c) will be more (ratio > 1) or less (ratio < 1) than the allocations in (a) and (b).

15.43 As the DL hours component decreases, the denominator in Eq. [15.7], basis level, will decrease. Thus, the rate for a department using automation to replace direct labor hours will increase in the computation

$$\text{Rate} = \frac{\text{indirect costs}}{\text{basis level}}$$

The increased use of indirect labor for automation requires that these costs be tracked directly when possible and the remainder allocated with bases other than DLH.

15.44 The ABC method is useful in control of the cost of production, rather than just estimating where the costs are incurred. From this viewpoint, ABC is considered more of a control tool of management as compared to an accounting technique.

15.45 (a)

$$\text{Rate} = \frac{\$1 \text{ million}}{16{,}500 \text{ guests}} = \$60.61 \text{ per guest}$$

Charge = (# guests) (rate)

Site	A	B	C	D
Guests	3,500	4,000	8,000	1,000
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-night	10,500	10,000	10,000	4,750
Charge	$297,885	283,700	283,700	134,757

(c) The actual indirect cost charge to sites C and D are significantly different using the two methods. Another basis could be guest-dollars, that is, total amount of money a guest (or group) spends, if this could be tracked.

(d) There is no difference at all in the actual indirect cost amounts charged since the actual distribution of the $1 million to each hotel is not used in any of the computations in (a) or (b). However, the allocation variances of over- and under-allocation will change appreciably. Using part (b) actual charges, allocation variances change as follows.

Site	A	B	C	D
Actual charge, part (b), $	297,885	283,700	283,700	134,757
10% of budget method:				
Allocated, $	200,000	300,000	400,000	100,000
Variance, $	–97,885	+16,300	+116,300	–34,757
30%/20% of budget method:				
Allocated, $	200,000	300,000	300,000	200,000
Variance, $	–97,885	+16,300	+16,300	+65,243

Variance = allocated amount – actual charge
(Note: + is over-allocation; – is under-allocation)

15.46 Rates are determined first.

$$\text{DLH rate} = \frac{\$400{,}000}{51{,}300} = \$7.80 \text{ per hour}$$

$$\text{Old cycle time rate} = \frac{\$400{,}000}{97.3} = \$4{,}111 \text{ per second}$$

$$\text{New cycle time rate} = \frac{\$400{,}000}{45.7} = \$8{,}752.74 \text{ per second}$$

Actual charges = (rate)(basis level)

Line	10	11	12
DLH basis	$156,000	99,060	145,080
Old cycle time	53,443	229,394	117,164
New cycle time	34,136	148,797	217,068

The actual charge patterns are significantly different for all 3 bases.

15.47 (a) Workforce basis rate = \$200,200/1,400
= \$143 per employee

CA: 143(900) = \$128,700 AZ: 143(500) = \$ 71,500

(b) Accident basis rate = \$200,200/560
= \$357.50 per accident

CA: 357.50(425) = \$151,938 AZ: 357.50(135) = \$ 48,262

This basis lowers the Arizona charge since it has fewer accidents per employee relative to California site.

CA: 425/900 = 0.472 AZ: 135/500 = 0.270

(c) ABC: 80% of \$200,200 is \$160,160

Generation-area accident basis:

Rate: \$160,160/530 = \$302.19 per accident

CA: 302.19(405) = \$122,387
AZ: 302.19(125) = \$ 37,774

Classic: 20% of \$200,200 is \$40,040

Employee rate = \$40,040/900 = \$44.49 per employee

CA: 44.49(600) = \$26,693
AZ: 44.49(300) = \$13,346

Total actual charges:

CA: 122,387 + 26,693 = \$149,080
AZ: 37,774 + 13,346 = \$ 51,120

Comparison for (a), (b) and (c):

Basis	Employees	Accidents	80% - 20% Split
CA	\$128,700	\$151,938	\$149,080
AZ	\$ 71,500	\$ 48,262	\$ 51,120

The difference is not great for the accident basis compared to the split-basis approach.

15.48 $C_2 = 400{,}000(6950/6059)$

$= \$458{,}822$

Answer is (c)

15.49 $89{,}750 = 75{,}000(I_2/1027)$

$I_2 = 1229$

Answer is (a)

15.50 $C_2 = 2100\ (200/50)^{0.76}$
$= \$6023$

Answer is (b)

15.51 $\text{Cost}_{\text{now}} = 15{,}000\ (1164/1092)\ (2)^{0.65}$
$= \$25{,}089$

Answer is (b)

Case Study #1 Solution

1. An increase in the chemical cost moves the optimum dosage to the left, or decreases the optimum dosage in Figure 15-3. For example, at a cost of $0.25 per kilogram, the optimum dosage is about 4.7 mg/L (by trial and error using spreadsheet and total cost equation of $C_T = -0.0024F^3 + 0.0749F^2 – 0.548F + 3.791$).

2. An increase in backwash water cost raises the backwash water cost line and moves the optimum dosage to the right in Figure 15-3. For example, doubling the cost of water from $0.0608/m^3 to $0.1216/m^3 moves the optimum dosage to 7.2 mg/L (by trial and error).

3. The chemical cost at 10 mg/L is $1.83/1000 m^3 of water produced

4. The backwash water cost at 14 mg/L is $0.71/1000 m^3 of water produced by using 14 mg/L in Eq. [15.10].

5. For $C_C = 0.21$ in Eq. [15.11], C_T in Eq. [15.12] is:
   $C_T = –0.0024F^3 + 0.0749F^2 – 0.588F + 3.791$.
   At 6 mg/L, total cost is: C_T = $2.44.

6. The minimum dosage would be 8 mg/L at a chemical cost of $0.06/kg. Determined by trial and error using $C_T = –0.0024F^3 + 0.0749F^2 – 0.738F + 3.791$.

Case Study #2 Solution

1. DLH basis

Standard: rate = $\dfrac{\$1.67 \text{ million}}{187{,}500 \text{ hrs}}$ = $8.91/DLH

Premium: rate = $\dfrac{\$3.33 \text{ million}}{125{,}000 \text{ hrs}}$ = $26.64/DLH

Model	IDC rate	DL hours	IDC allocation	Direct material	Direct Labor	Total cost	Price, ~1.10 x cost
Std	$8.91	0.25	$2.23/un	2.50/m	$5/un	$9.73	10.75
Prm	26.64	0.50	13.32	3.75	10	27.07	29.75

2.

Cost pool	Cost driver	Volume of driver	Total cost/year	Cost per activity
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	Activity	IDC allocation	Activity	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) They were right on IDC allocation under ABC, but they were wrong on traditional where the cost is ~ 1/3 and IDC is ~1/6.

	Allocation	
Model	Traditional	ABC
Standard	$2.23/unit	$3.57/unit
Premium	13.32	9.28

b) Cost versus Profit comment – Wrong if old prices are retained.
Under ABC standard model loses $0.32/unit. Price for standard should go up.
Price for standard should go up. Premium makes good profit at current price under ABC ($7.72/unit).

c) Premium require more activities and operations
Wrong : Premium is lower in cost drivers of 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.

Chapter 16
Depreciation Methods

Solutions to Problems

16.1 Other terms are: recovery rate, realizable value or market value; depreciable life; and personal property

16.2 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.

16.3 MACRS has set n values for depreciation by property class. These are commonly different – usually shorter – than the actual, anticipated useful life of an asset.

16.4 Asset depreciation is a deductible amount in computing income taxes for a corporation, so the taxes will be reduced. Thus PW or AW may become positive when the taxes due are lower.

16.5 (a) Quoting Publication 946, 2003 version: "Depreciation is an annual income tax deduction that allows you to recover the cost and 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.

16.6 (a) Quoting the glossary under the taxes-businesses section of the website: "A decrease in the value of an asset through age, use, and deterioration. In accounting terminology, depreciation is a deduction or expense claimed for this decrease in value."

(b) "A yearly deduction or depreciation on the cost of certain assets. You can claim CCA for tax purposes on the assets of a business such as buildings or equipment, as well as on additions or improvements, if these assets are expected to last for some years." It is the equivalent of tax depreciation in the USA.

(c) “Real property includes:

- a mobile home or floating home and any leasehold or proprietary interest therein.
- in Quebec, immovable property and every lease thereof; and
- in any other place in Canada, all land, buildings of a permanent nature, and any interest in real property.“

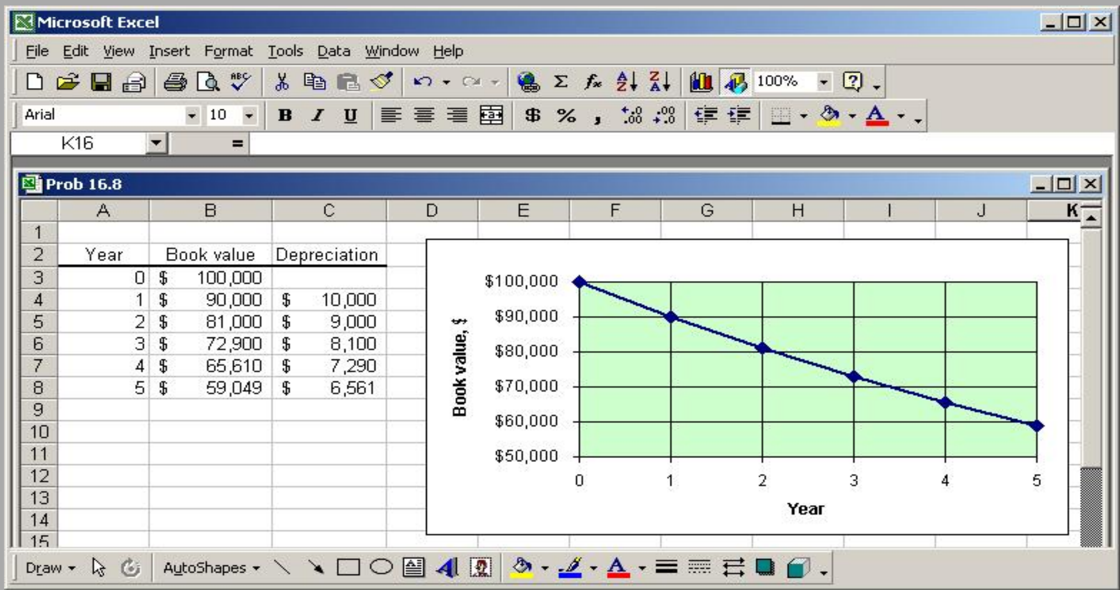
16.7 (a) B = \$350,000 + 40,000 = \$390,000
n = 7 years
S = 0.1(350,000) = \$35,000

(b) Remaining life = 4 years
Market value = \$45,000
Book Value = \$390,000(1 – 0.65)
= \$136,500

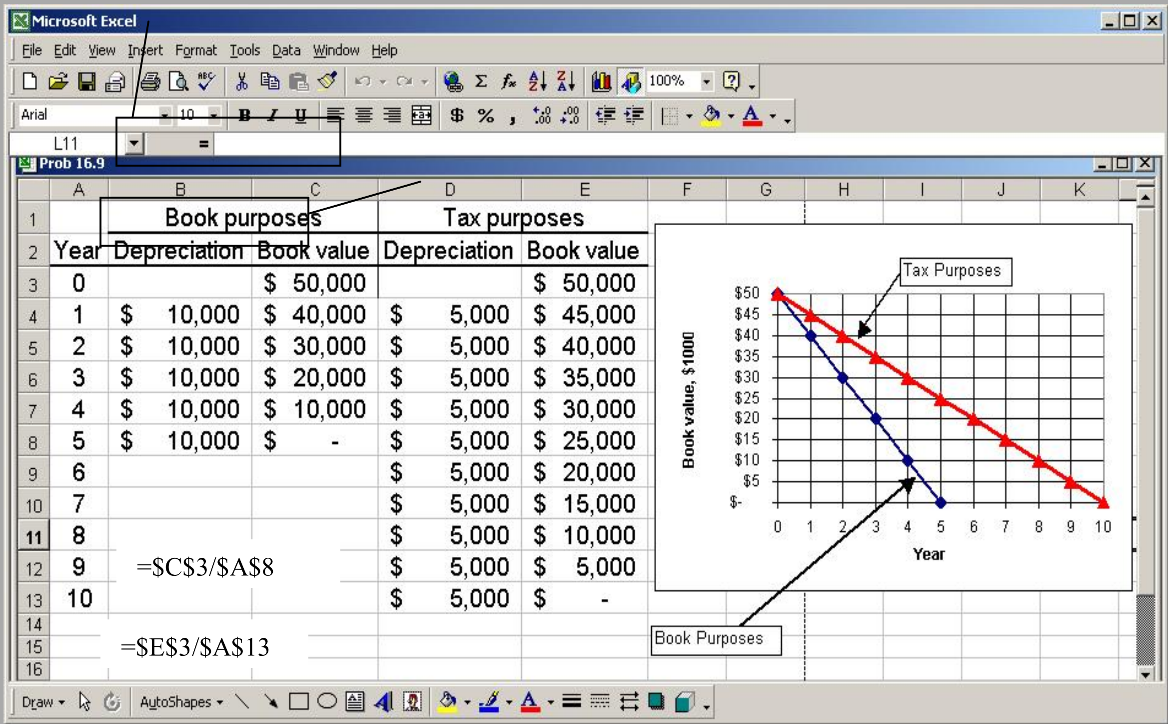
16.8

Year	Book Value	Part (a) Annual Depreciation	Part (b) Depreciation Rate
0	\$100,000	0	-----
1	90,000	\$10,000	10 %
2	81,000	9000	9
3	72,900	8100	8.1
4	65,610	7290	7.3
5	59,049	6561	6.56

(c) Book value = \$59,049 and market value = \$24,000.
(d) Plot year versus book value in dollars for the table above



16.9 Write the cell equations to determine depreciation of \$10,000 per year for book purpose and \$5000 per year for tax purposes and use Excel x-y scatter graph to plot the book values.



	Book purposes		Tax purposes	
Year	Depreciation	Book value	Depreciation	Book value
0		\$ 50,000		\$ 50,000
1	\$ 10,000	\$ 40,000	\$ 5,000	\$ 45,000
2	\$ 10,000	\$ 30,000	\$ 5,000	\$ 40,000
3	\$ 10,000	\$ 20,000	\$ 5,000	\$ 35,000
4	\$ 10,000	\$ 10,000	\$ 5,000	\$ 30,000
5	\$ 10,000	\$ -	\$ 5,000	\$ 25,000
6			\$ 5,000	\$ 20,000
7			\$ 5,000	\$ 15,000
8			\$ 5,000	\$ 10,000
9			\$ 5,000	\$ 5,000
10			\$ 5,000	\$ -

16.10 (a) By hand: B = \$400,000 S = 0.1(300,000) = \$30,000

D_t = (400,000-30,000)/8 = \$46,250 per year t (t = 1,…,8)
BV_4 = 400,000 – 4(46,250) = \$215,000

(b) Using Excel: Set up cell equations for depreciation and book value to obtain the same answers as in (a). Spreadsheet shown below.

(c) Change the cell values to B= \$350,000 (C3) and n = 5 (C6). Use the same relations.

S = \$35,000 D_t = \$83,000 BV_4 = \$118,000

One spreadsheet is used here to indicate answers to both parts.

Prob 16.10

	Part (b)	Part (c)		Part (b)	Part (c)
Purchase	$ 300,000	$350,000	Salvage = 10% of purchase =	$ 30,000	$ 35,000
Installation	$ 100,000	$100,000			
Basis, B	$ 400,000	$450,000			
Life, years	8	5	SL depreciation = (B-S)*d =	$ 46,250	$ 83,000
Depr rate, d	0.125	0.20			
			BV after 4 years = B - 4*depr =	$ 215,000	$118,000

16.11 (a) $D_t = \dfrac{12{,}000 - 2000}{8} = \$1250$ (b) $BV_3 = 12{,}000 - 3(1250) = \$8250$ (c) $d = 1/n = 1/8 = 0.125$

16.12 $BV_5 = 200{,}000 - 5 * \text{SLN}(200000,10000,7)$ Answer is $64,285.71

16.13 Use the spreadsheet below.

(a) $BV_4 = \$450{,}000$

(b) Loss = BV_4 - selling price = 450,000 – 75,000 = $375,000

(c) Two more years when book value is $300,000

Prob 16.13

Year	Year	SL Depr.	Book value
0	2004		$ 750,000
1	2005	$75,000	$ 675,000
2	2006	$75,000	$ 600,000
3	2007	$75,000	$ 525,000
4	2008	$75,000	$ 450,000
5	2009	$75,000	$ 375,000
6	2010	$75,000	$ 300,000
7	2011	$75,000	$ 225,000
8	2012	$75,000	$ 150,000
9	2013	$75,000	$ 75,000
10	2014	$75,000	$ -

16.14 (a) B = \$50,000, n = 4, S = 0, d = 0.25

$Year_t$	D_t	Accumulated D_t	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

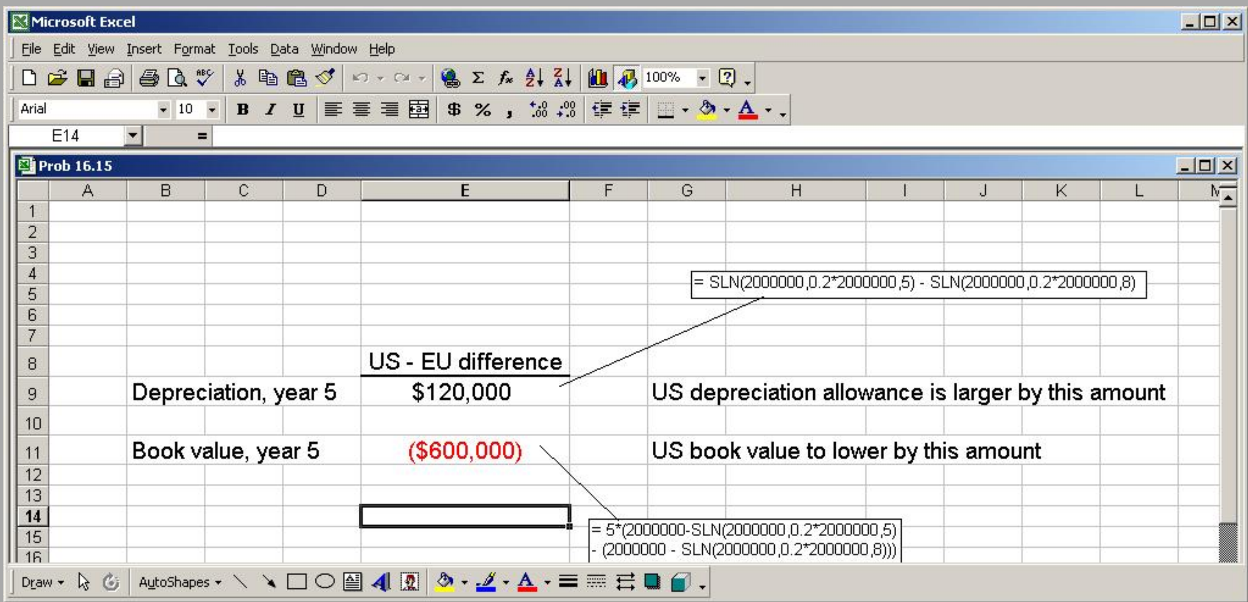
(b) S = \$16,000, d = 0.25, B - S = \$34,000

Year	D_t	Accumulated D_t	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

Plot year versus D_t, accumulated D_t and BV_t on one graph for each salvage value.

(c) Spreadsheets for S = 0 and S = \$16,000 provide the same answers as above.

16.15 Use a difference relation (US minus EU) for depreciation and BV in year 5 with the SLN function.



16.16 d is 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 $d(1-d)^{t-1}$.

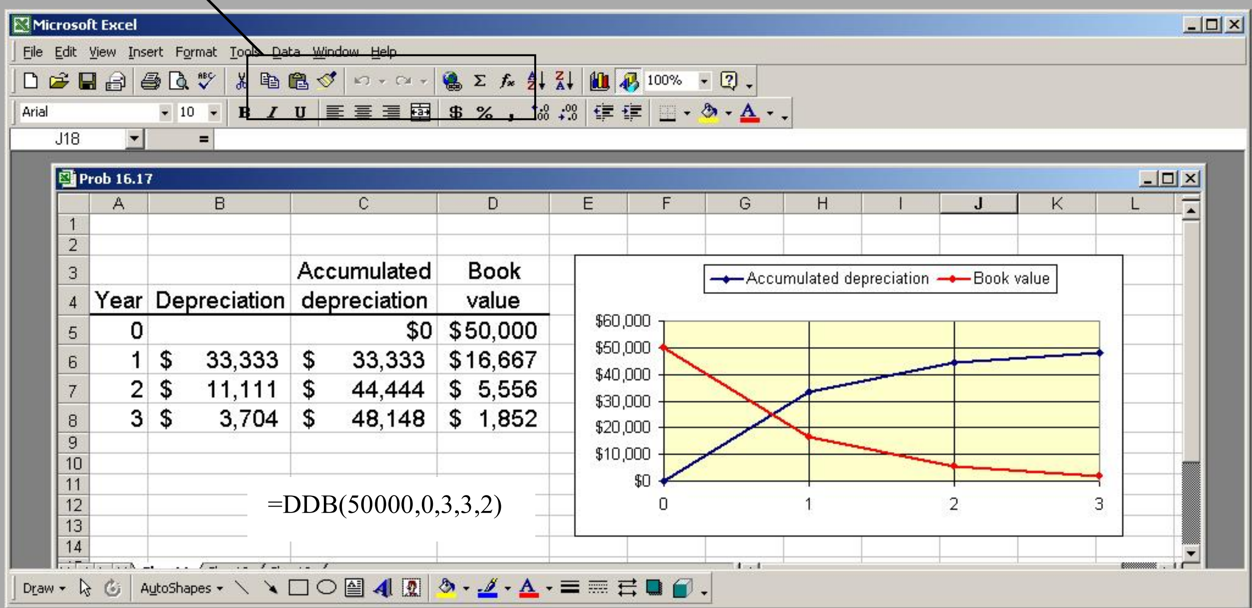
16.17 (a) B = \$50,000, n = 3, d = 2/n = 2/3 = 0.6667 for DDB

Annual depreciation = 0.6667(BV of previous year)

Year	Depreciation, Eq. [16.5]	Accumulated depreciation	Book value
0	-	-	\$50,000
1	\$33,335	\$33,335	16,667
2	11,112	44,447	5,555
3	3,704	48,151	1,851

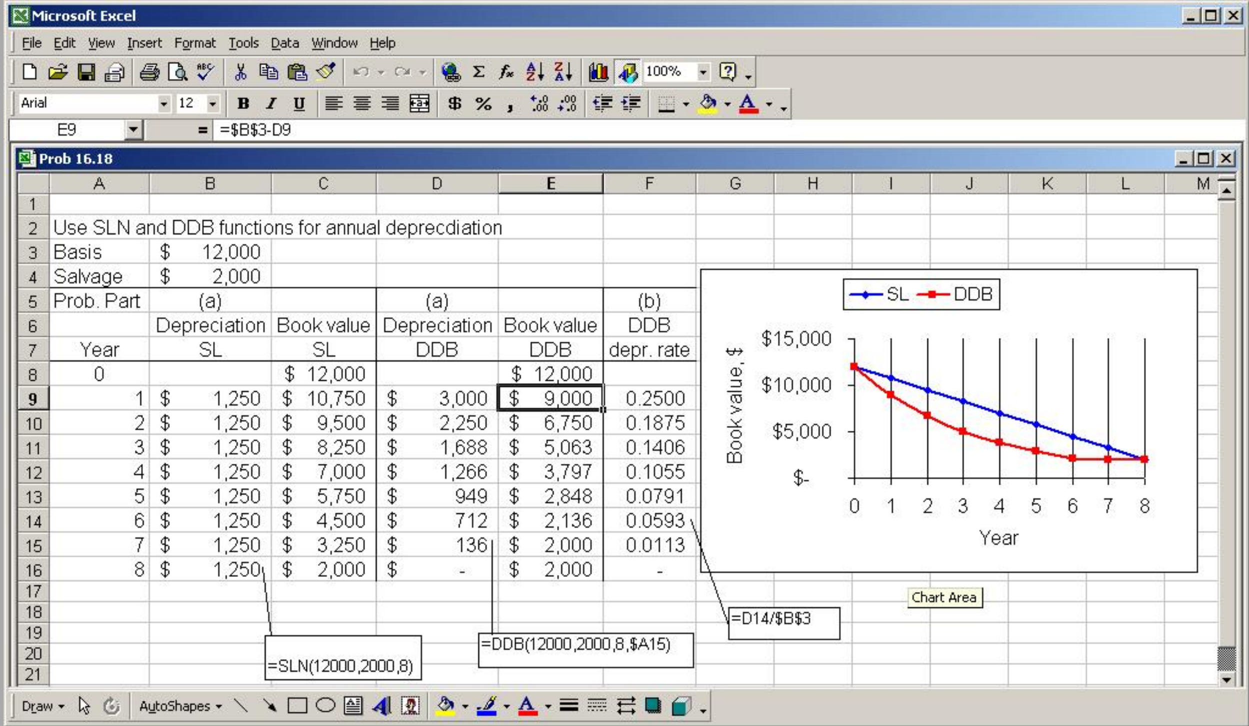
16.17 (cont)

(b) Use the function DDB(50000,0,3,t,2) for annual DDB depreciation in column B. The plot is developed using Excel's xy scatter chart function



Year	Depreciation	Accumulated depreciation	Book value
0		\$0	\$50,000
1	\$ 33,333	\$ 33,333	\$16,667
2	\$ 11,111	\$ 44,444	\$ 5,556
3	\$ 3,704	\$ 48,148	\$ 1,852

16.18 Set up spreadsheet; use SL and DDB functions; then plot the annual depreciation.



Microsoft Excel — Prob 16.18

E9 = =$B$3-D9

Use SLN and DDB functions for annual deprecdiation

Basis	$	12,000
Salvage	$	2,000

Prob. Part	(a)		(a)		(b)
	Depreciation	Book value	Depreciation	Book value	DDB
Year	SL	SL	DDB	DDB	depr. rate
0		$ 12,000		$ 12,000	
1	$ 1,250	$ 10,750	$ 3,000	$ 9,000	0.2500
2	$ 1,250	$ 9,500	$ 2,250	$ 6,750	0.1875
3	$ 1,250	$ 8,250	$ 1,688	$ 5,063	0.1406
4	$ 1,250	$ 7,000	$ 1,266	$ 3,797	0.1055
5	$ 1,250	$ 5,750	$ 949	$ 2,848	0.0791
6	$ 1,250	$ 4,500	$ 712	$ 2,136	0.0593
7	$ 1,250	$ 3,250	$ 136	$ 2,000	0.0113
8	$ 1,250	$ 2,000	$ -	$ 2,000	-

16.19 B = \$800,000; n = 30; S = 0

(a) Straight line depreciation:

$$D_t = \frac{800{,}000}{30} = \$26{,}667 \qquad t = 5,\ 10,\ 25, \text{ and all other years}$$

(b) Double declining balance method: d = 2/n = 2/30 = 0.06667

$$D_5 = 0.06667(800{,}000)(1–0.06667)^{5-1} = \$40{,}472$$
$$D_{10} = 0.06667(800{,}000)(1–0.06667)^{10-1} = \$28{,}664$$
$$D_{25} = 0.06667(800{,}000)(1–0.06667)^{25–1} = \$10{,}183$$

The annual depreciation values are significantly different for SL and DDB.

(c) $D_{30} = 800{,}000(1–0.06667)^{30} = \$100{,}959$

16.20 SL: $d_t = 0.20$ of B = \$25,000 Fixed rate: DB with d = 0.25 DDB: d = 2/5 = 0.40

$BV_t = 25{,}000 - t(5{,}000)$ $BV_t = 25{,}000(0.75)^t$ $BV_t = 25{,}000(0.60)^t$

		Declining balance methods	
Year, t	SL	125% SL	200% SL
d	0.20	0.25	0.40
0	\$25,000	\$25,000	\$25,000
1	20,000	18,750	15,000
2	15,000	14,062	9,000
3	10,000	10,547	5,400
4	5,000	7,910	3,240
5	0	5,933	1,944

16.21 (a) For DDB, use d = 2/18 = 0.11111

$D_2 = 0.11111(182{,}000)(1 - 0.11111)^{2-1} = \$17{,}975$

$D_{18} = 0.11111(182{,}000)(1 - 0.11111)^{18-1} = \$2730$

Compare BV_{17} with S = \$50,000. By Eq. [16.8]

$BV_{17} = 182{,}000(1 - 0.11111)^{17} = \$24{,}575$

It is not okay to use D_{18} = \$2730 because the BV has already reached the estimated S of \$50,000.

For DB, calculate d via Eq. [16.11].

$d = 1 - (50{,}000/182{,}000)^{1/18} = 0.06926$

$D_2 = 0.06926(182{,}000)(0.93074)^1 = \$11{,}732$

$D_{18} = 0.06926(182{,}000)(1 - 0.06926)^{18-1} = \$3721$

(b) For DDB: same values are obtained, with D_{18} = \$0 in cell B22 here.

For DB: DB function uses an implied 3-decimal value of d = 0.069, so the depreciation amounts are slightly different than above: D_2 = \$11,691 (cell D6) and D_{18} = \$3724 by Excel.

Prob 16.21

B5 = =DDB(182000,50000,18,$A5,2)

Year	DDB Depreciation Depreciation	 Book value	DB Depreciation
0		$ 182,000	
1	$ 20,222	$ 161,778	$12,558
2	$ 17,975	$ 143,802	$11,691
3	$ 15,978	$ 127,824	$10,885
4	$ 14,203	$ 113,622	$10,134
5	$ 12,625	$ 100,997	$9,435
6	$ 11,222	$ 89,775	$8,784
7	$ 9,975	$ 79,800	$8,177
8	$ 8,867	$ 70,933	$7,613
9	$ 7,881	$ 63,052	$7,088
10	$ 7,006	$ 56,046	$6,599
11	$ 6,046	$ 50,000	$6,144
12	$ -	$ 50,000	$5,720
13	$ -	$ 50,000	$5,325
14	$ -	$ 50,000	$4,958
15	$ -	$ 50,000	$4,615
16	$ -	$ 50,000	$4,297
17	$ -	$ 50,000	$4,001
18	$ -	$ 50,000	$3,724

=DB(182000,50000,18,$A5)

16.22 The implied d is 0.06926. The factor for the DDB function is

$$\begin{aligned} \text{factor} &= \text{implied DB rate / SL rate} \\ &= 0.06926 / (1/18) \\ &= 1.24668 \end{aligned}$$

The DDB function is DDB(182000,50000,18,18,1.24668)

$D_{18} = 0.06926(182{,}000)(0.93074)^{17} = \$3721$

The D_{18} value must be acceptable since d was calculated using estimated values.

16.23 (a) $d = 1.5/12 = 0.125$

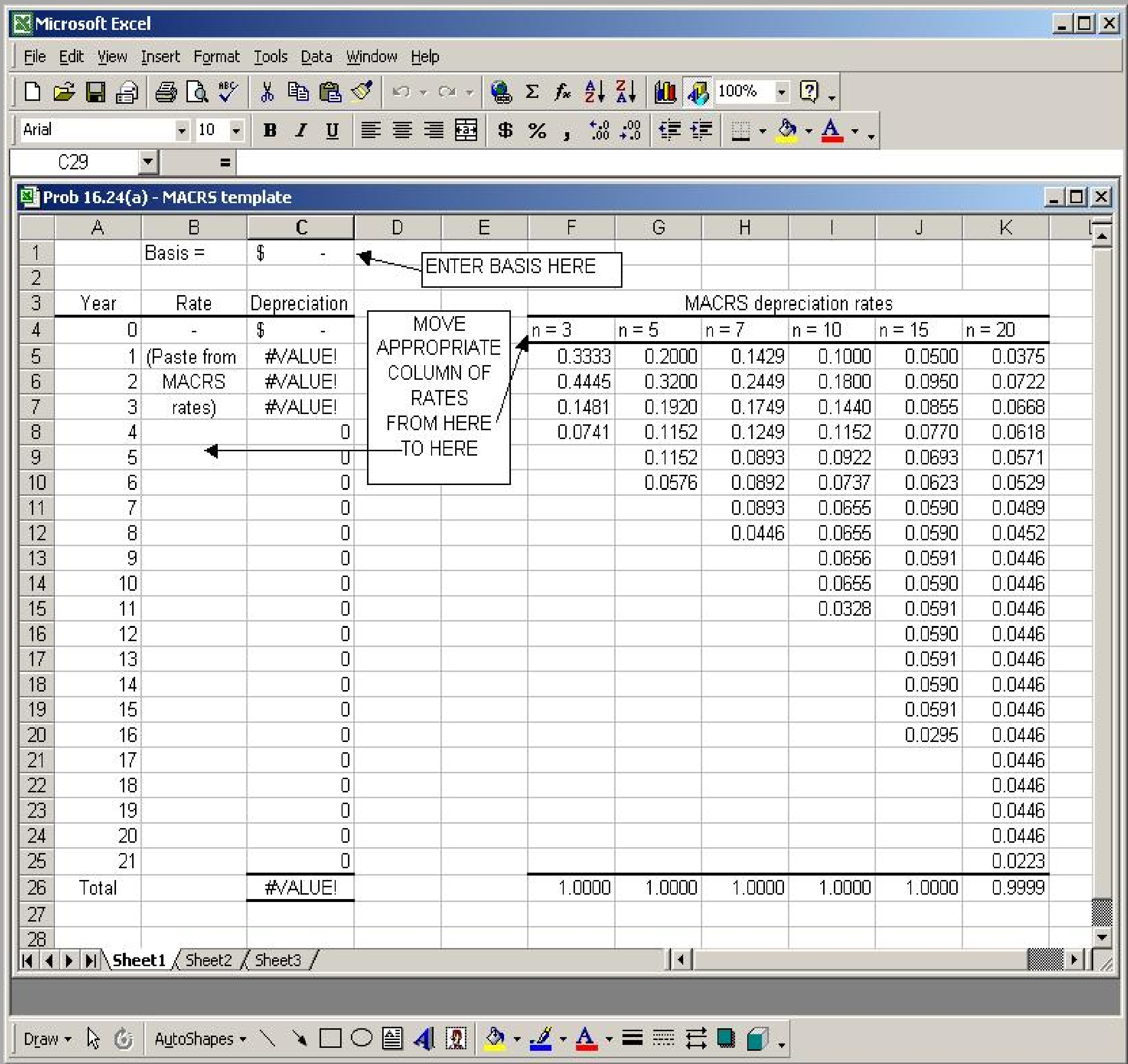
$D_1 = 0.125(175{,}000)(0.875)^{1-1} = \$21{,}875$ $\quad$ $BV_1 = 175{,}000(0.875)^1 = \$153{,}125$

$D_{12} = 0.125(175{,}000)(0.875)^{12-1} = \$5{,}035$ $\quad$ $BV_{12} = 175{,}000(0.875)^{12} = \$35{,}248$

(b) The 150% DB salvage value of $35,248 is larger than S = $32,000.

(c) = DDB(175000,32000,12,t,1.5) for t = 1, 2, …, 12

16.24 One version of a MACRS depreciation template is shown. Cut and paste the appropriate rate series into column B, enter the basis in cell C1 and the results are presented.



	A	B	C	D	E	F	G	H	I	J	K
1		Basis =	$ -								
2											
3	Year	Rate	Depreciation			MACRS depreciation rates					
4	0	-	$ -			n = 3	n = 5	n = 7	n = 10	n = 15	n = 20
5	1	(Paste from	#VALUE!			0.3333	0.2000	0.1429	0.1000	0.0500	0.0375
6	2	MACRS	#VALUE!			0.4445	0.3200	0.2449	0.1800	0.0950	0.0722
7	3	rates)	#VALUE!			0.1481	0.1920	0.1749	0.1440	0.0855	0.0668
8	4		0			0.0741	0.1152	0.1249	0.1152	0.0770	0.0618
9	5		0				0.1152	0.0893	0.0922	0.0693	0.0571
10	6		0				0.0576	0.0892	0.0737	0.0623	0.0529
11	7		0					0.0893	0.0655	0.0590	0.0489
12	8		0					0.0446	0.0655	0.0590	0.0452
13	9		0						0.0656	0.0591	0.0446
14	10		0						0.0655	0.0590	0.0446
15	11		0						0.0328	0.0591	0.0446
16	12		0							0.0590	0.0446
17	13		0							0.0591	0.0446
18	14		0							0.0590	0.0446
19	15		0							0.0591	0.0446
20	16		0							0.0295	0.0446
21	17		0								0.0446
22	18		0								0.0446
23	19		0								0.0446
24	20		0								0.0446
25	21		0								0.0223
26	Total		#VALUE!			1.0000	1.0000	1.0000	1.0000	1.0000	0.9999

16.25 Personal property: manufacturing equipment, construction equipment, company car
Real property: warehouse building; rental house (not land of any kind)

16.26 B = \$500,000 S = \$100,000 n = 10 years

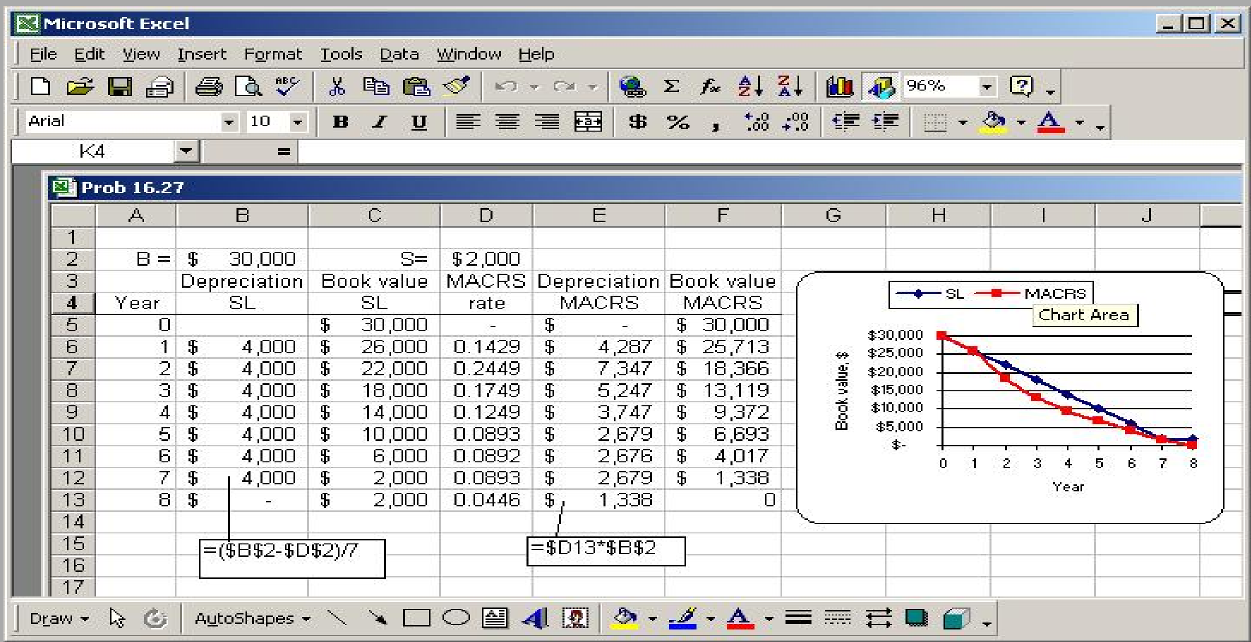
SL:	$d = 1/n = 1/10$	$D_1 = (B-S)/n = (500{,}000 - 100{,}000)/10 = \$40{,}000$
DDB:	$d = 2/10 = 0.20$	$D_1 = dB = 0.20(500{,}000) = \$100{,}000$
150% DB:	$d = 1.5/10 = 0.15$	$D_1 = dB = 0.15(500{,}000) = \$75{,}000$
MACRS:	$d = 0.1$	$D_1 = 0.1(500{,}000) = \$50{,}000$

The first-year tax depreciation amounts vary considerably from \$40,000 to \$100,000.

16.27 (a) SL Depreciation each year = (30,000 – 2000)/7 = \$4000

	Straight line method		MACRS method		
Year	Depr	Book value	d rate	Depr	Book value
0	-	\$30,000	-	-	\$30,000
1	\$4,000	26,000	0.1429	\$4,287	25,713
2	4,000	22,000	0.2449	7,347	18,366
3	4,000	18,000	0.1749	5,247	13,119
4	4,000	14,000	0.1249	3,747	9,372
5	4,000	10,000	0.0893	2,679	6,693
6	4,000	6,000	0.0892	2,676	4,017
7	4,000	2,000	0.0893	2,679	1,338
8	0	2,000	0.0446	1,338	0

(b) Calculate the BV values and plot using the xy scatter chart.



	A	B	C	D	E	F
2	B =	\$ 30,000	S=	\$2,000		
3		Depreciation	Book value	MACRS	Depreciation	Book value
4	Year	SL	SL	rate	MACRS	MACRS
5	0		\$ 30,000	-	\$ -	\$ 30,000
6	1	\$ 4,000	\$ 26,000	0.1429	\$ 4,287	\$ 25,713
7	2	\$ 4,000	\$ 22,000	0.2449	\$ 7,347	\$ 18,366
8	3	\$ 4,000	\$ 18,000	0.1749	\$ 5,247	\$ 13,119
9	4	\$ 4,000	\$ 14,000	0.1249	\$ 3,747	\$ 9,372
10	5	\$ 4,000	\$ 10,000	0.0893	\$ 2,679	\$ 6,693
11	6	\$ 4,000	\$ 6,000	0.0892	\$ 2,676	\$ 4,017
12	7	\$ 4,000	\$ 2,000	0.0893	\$ 2,679	\$ 1,338
13	8	\$ -	\$ 2,000	0.0446	\$ 1,338	0

=(\$B\$2-\$D\$2)/7

=\$D13*\$B\$2

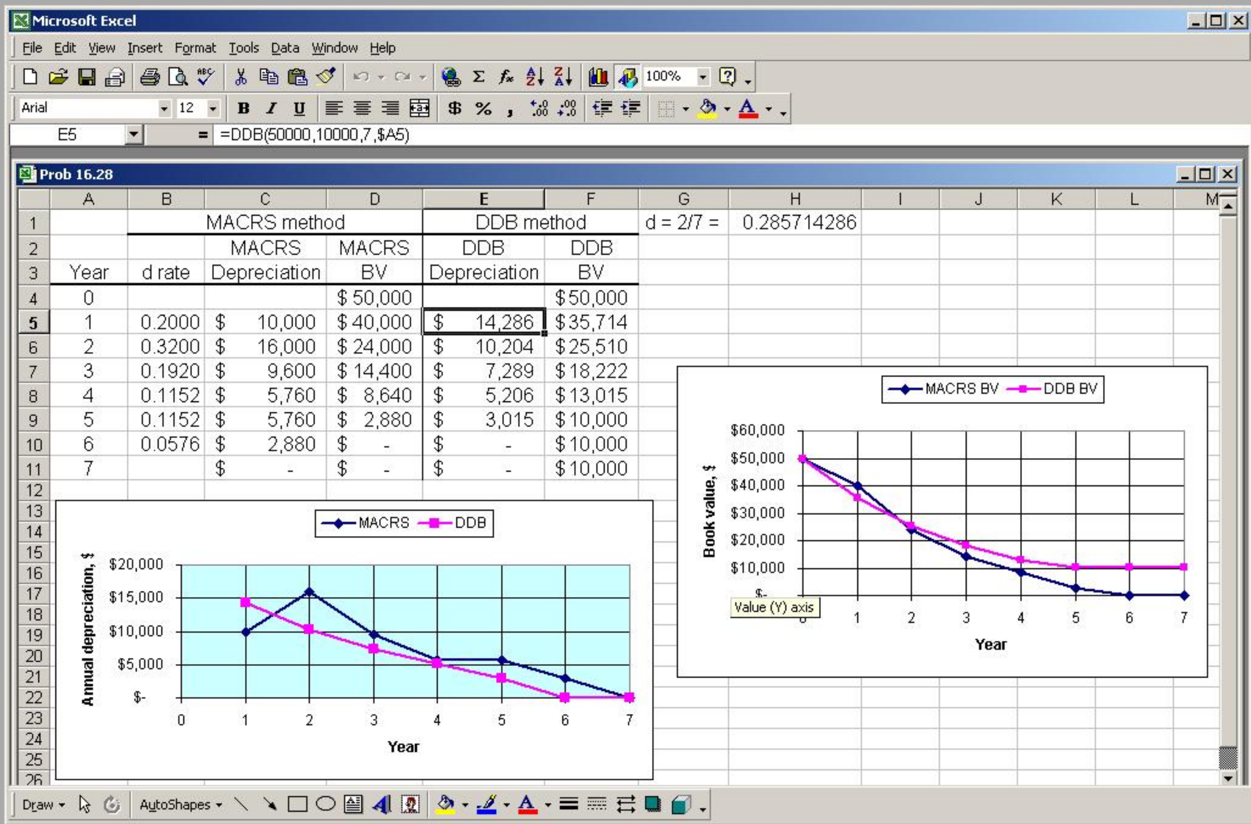
16.28 (a) and (b) For MACRS use Table 16.2 rates for n = 5. For DDB, with d = 0.2857, stop depreciating at S = $10,000.

	(a) MACRS			(b) DDB	
Year	d rate	Depr	BV	Depr	BV
0	-	-	$50,000	-	$50,000
1	0.20	$10,000	40,000	$14,285	35,715
2	0.32	16,000	24,000	10,204	25,511
3	0.192	9,600	14,400	7,288	18,222
4	0.1152	5,760	8,640	5,206	13,016
5	0.1152	5,760	2,880	3,016*	10,000
6	0.0576	2,880	0	-	10,000
7	-		0	-	10,000

*$D_5 = 0.2857(13,016) = \$3,719$ is too large since BV < $10,000

MACRS depreciates to BV = 0 while DDB stops at S = $10,000.

(c) Plot the depreciation and BV columns on x–y scatter charts.



	A	B	C	D	E	F	G	H
1		MACRS method			DDB method		d = 2/7 =	0.285714286
2			MACRS	MACRS	DDB	DDB		
3	Year	d rate	Depreciation	BV	Depreciation	BV		
4	0			$ 50,000		$50,000		
5	1	0.2000	$ 10,000	$ 40,000	$ 14,286	$35,714		
6	2	0.3200	$ 16,000	$ 24,000	$ 10,204	$25,510		
7	3	0.1920	$ 9,600	$ 14,400	$ 7,289	$18,222		
8	4	0.1152	$ 5,760	$ 8,640	$ 5,206	$13,015		
9	5	0.1152	$ 5,760	$ 2,880	$ 3,015	$10,000		
10	6	0.0576	$ 2,880	$ -	$ -	$10,000		
11	7		$ -	$ -	$ -	$10,000		

16.29 For classical SL, n = 5 and

$D_t = 450{,}000/5 = \$90{,}000$

$BV_3 = 450{,}000 – 3(90{,}000) = \$180{,}000$

For MACRS, after 3 years for n = 5 sum the rates in Table 16.2.

$\Sigma D_t = 450{,}000(0.712) = \$320{,}400$

$BV_3 = \$450{,}000-320{,}400 = \$129{,}600$

The difference is $50,400, which has not been removed by classical SL depreciation.

16.30 Use n = 39 with d = 1/39 = 0.02564 in all 38 years except years 1 and 40 as specified by MACRS.

Year	d rate	Depreciation
1	0.01391	$25,038
2-39	0.02564	46,152
40	0.01177	21,186

16.31 (a) For MACRS, use n = 5 and the Table 16.2 rates with B = $100,000.
For SL, use n = 10 with d = 0.05 in years 1 and 11 and d = 0.1 in all others

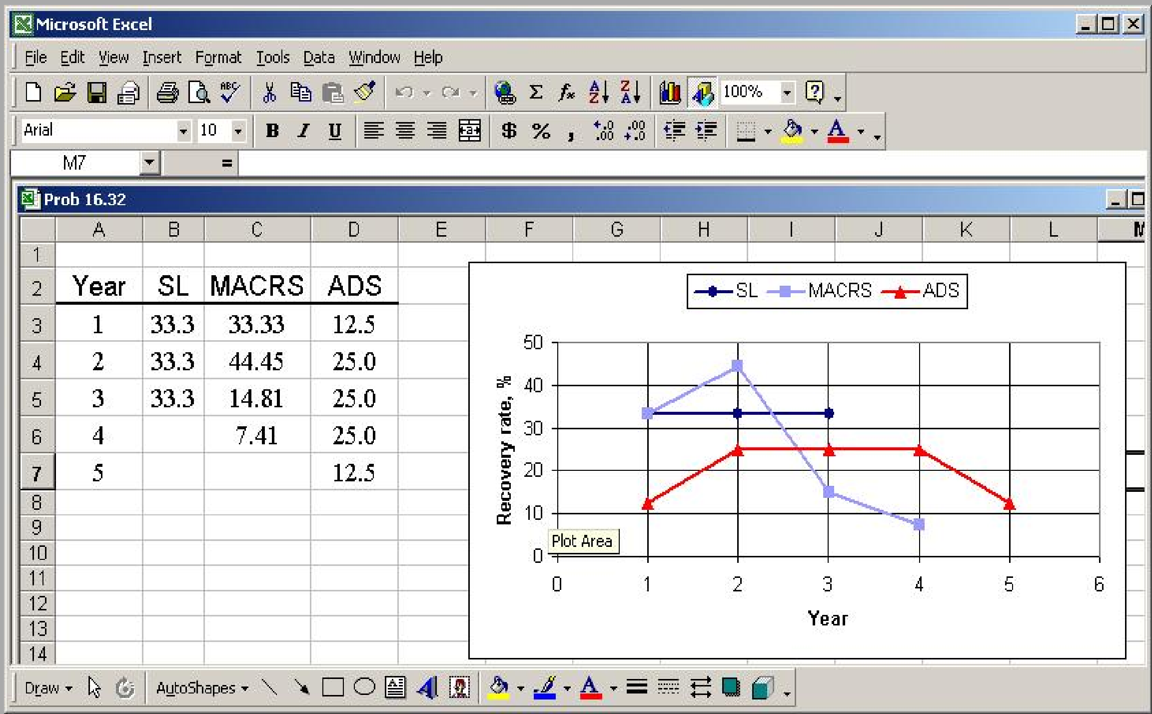
	MACRS			SL		
Year	d	Depr	BV	d	Depr	BV
0	-	-	$100,000	-	-	$100,000
1	0.2000	$20,000	80,000	0.05	$ 5,000	95,000
2	0.3200	32,000	48,000	0.10	10,000	85,000
3	0.1920	19,200	28,800	0.10	10,000	75,000
4	0.1152	11,520	17,280	0.10	10,000	65,000
5	0.1152	11,520	5760	0.10	10,000	55,000
6	0.0576	5760	0	0.10	10,000	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

Plot the two BV columns on one graph manually and by Excel chart.

(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.

16.32 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



16.33 There is a larger depreciation allowance that is tax deductible, so more revenue is retained as net profit after taxes.

16.34 (a) Use Equation [16.15] for cost depletion factor.

p_t = 1,100,000/350,000 = $3.143 per ounce

Cost depletion, 3 years = 3.143(175,000) = $550,025

(b) Remaining investment = 1,100,000 – 550,025 = \$549,975

New p_t = 549,975/100,000 = \$5.50 per ounce

(c) Cost depletion: \$Depl = 35,000(5.50) = \$192,500

Percentage depletion: %Depl = 15% of gross income
= 0.15(35,000)(5.50) = \$28,875

From Equation [16.17], %Depl < \$Depl; depletion for the year is

\$Depl = \$192,500

16.35 Percentage depletion for copper is 15% of gross income, not to exceed 50% of taxable income.

Year	Gross* income	% Depl @ 15%	50% of TI	Allowed depletion
1	\$3,200,000	\$480,000	\$750,000	\$480,000
2	7,020,000	1,053,000	1,000,000	1,000,000
3	2,990,000	448,500	500,000	448,500

*GI = (tons)(\$/pound)(2000 pounds/ton)

16.36 (a) p_t = \$3.2/2.5 million = \$1.28 per ton
Percentage depletion is 5% of gross income each year

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

16.36 (cont)

Year	\$Depl, \$1.28 x tonnage per year	%Depl, 5% of GI	Selected
1	\$76,800	\$90,000	%Depl
2	64,000	62,500	\$Depl
3	74,240	101,500	%Depl
4	76,800	105,000	%Depl
5	83,200	130,000	%Depl

(b) Total depletion is \$490,500

% written off = 490,500/3.2 million = 15.33%

(c) Set up the spreadsheet with all needed data.

Microsoft Excel

E3 = =\$B3*\$J\$4

Prob 16.36(c)

	A	B	C	D	E	F	G	H	I	J
1			Income	Gross			Depl	Which		
2	Year	Tonnage	per ton	income	\$ depl	% depl	for year	depl?	Initial cost	\$ 3,200,000
3	1	60,000	30	1800000	\$76,800	\$ 90,000	\$ 90,000	%	Est amt, tons	2,500,000
4	2	50,000	25	1250000	\$64,000	\$ 62,500	\$ 64,000	\$	Cost depl rate/ton	\$ 1.280
5	3	58,000	35	2030000	\$74,240	\$101,500	\$101,500	%		
6	4	60,000	35	2100000	\$76,800	\$105,000	\$105,000	%	Depl rate, %	5%
7	5	65,000	40	2600000	\$83,200	\$130,000	\$130,000	%		
8							\$490,500		% written off	15.33%
9										

(d) The undepleted investment after 3 years:

3.2 million – (90,000 + 64,000 + 101,500) = \$2,944,500

New cost depletion factor is: p_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 (> %Depl)

year 5: 65,000(1.983) = \$127,595 (< %Depl)

Percentage depletion amounts are the same.

Conclusion: Select \$Depl for year 4 and %Depl in year 5.

% written off = \$503,280/3.2 million = 15.73%

16.37 $D = \frac{20{,}000 - 2000}{5} = \$3600$ per year

Answer is (a)

16.38 From table, depreciation factor is 17.49%.

$D = 35{,}000(0.1749) = \$6122$

Answer is (d)

16.39 $D = \frac{50{,}000 - 10{,}000}{5} = \$8000$ per year

$BV_3 = 50{,}000 - 3(8{,}000) = \$26{,}000$

Answer is (b)

16.40 The MACRS depreciation rates are 0.2 and 0.32.

$D_1 = 50{,}000(0.20) = \$10{,}000$

$D_2 = 50{,}000(0.32) = \$16{,}000$

$BV_2 = 50{,}000 - 10{,}000 - 16{,}000 = \$24{,}000$

Answer is (c)

16.41 By the straight line method, book value at end of asset's life MUST equal salvage value ($10,000 in this case).

Answer is (c)

16.42 Total depreciation = first cost – BV after 3 years
= 50,000 – 21,850 = $28,150

Answer is (d)

16.43 Straight line rate is always used as the reference.

Answer is (a)

Chapter 16 Appendix

Solutions to Problems

16A.1 The depreciation rate is from Eq. [16A.4] using SUM = 36.

t	d_t	D_t, euro	BV_t, euro
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

$$BV_1 = 12{,}000 - \left[\frac{1(8 - 0.5 + 0.5)}{36}\right](12{,}000 - 2000) = 9777.78 \text{ euro}$$

$$BV_2 = 12{,}000 - \left[\frac{2(8 - 1 + 0.5)}{36}\right](10{,}000) = 7833.33 \text{ euro}$$

16A.2 (a) Use B = \$150,000; n = 10; S = \$15,000 and SUM = 55.

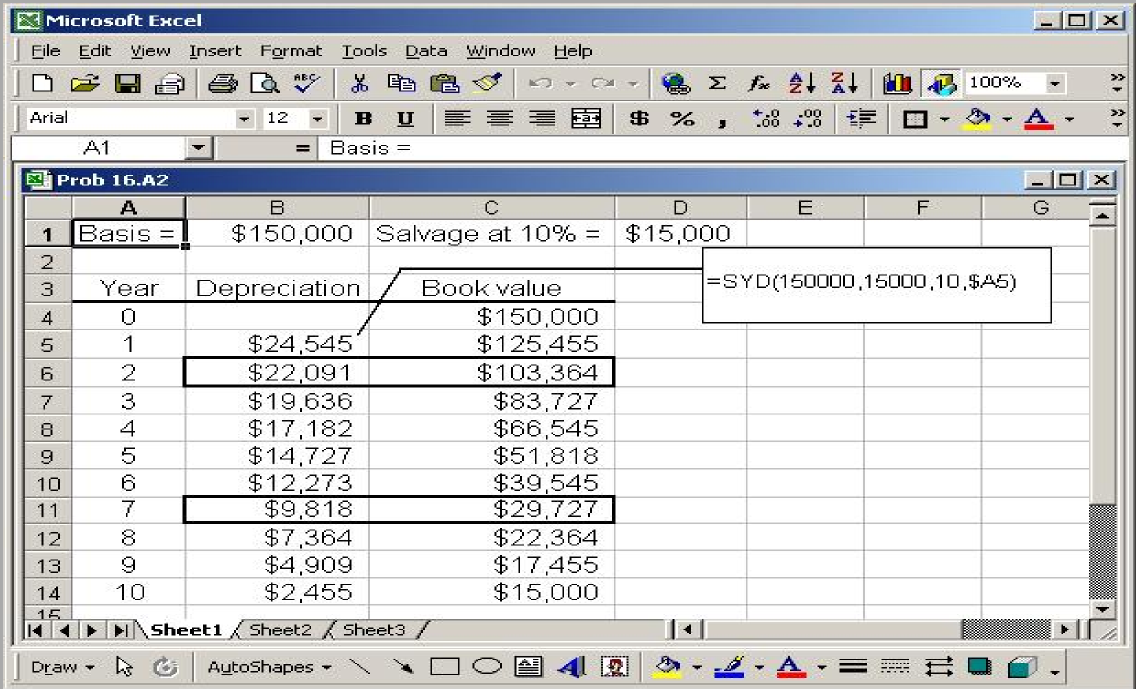
$$D_2 = \frac{10 - 2 + 1}{55}(150{,}000 - 15{,}000) = \$22{,}091$$

$$BV_2 = 150{,}000 - \left[\frac{2(10 - 1 + 0.5)}{55}\right](150{,}000 - 15{,}000) = \$103{,}364$$

$$D_7 = \frac{10 - 7 + 1}{55}(150{,}000 - 15{,}000) = \$9818$$

$$BV_7 = 150{,}000 - \left[\frac{7(10 - 3.5 + 0.5)}{55}\right](150{,}000 - 15{,}000) = \$29{,}727$$

(b)



A	B	C	D
Basis =	$150,000	Salvage at 10% =	$15,000
Year	Depreciation	Book value	
0		$150,000	
1	$24,545	$125,455	
2	$22,091	$103,364	
3	$19,636	$83,727	
4	$17,182	$66,545	
5	$14,727	$51,818	
6	$12,273	$39,545	
7	$9,818	$29,727	
8	$7,364	$22,364	
9	$4,909	$17,455	
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.3] 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.4] and t = 4:

$$d_4 = \frac{6 - 4 + 1}{21} = 3/21 = 1/7$$

$$\begin{aligned} D_4 &= d_4(B - S) \\ &= (3/21)(12{,}000 - 1800) \\ &= \$1457 \end{aligned}$$

16A.4 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 Depr
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)

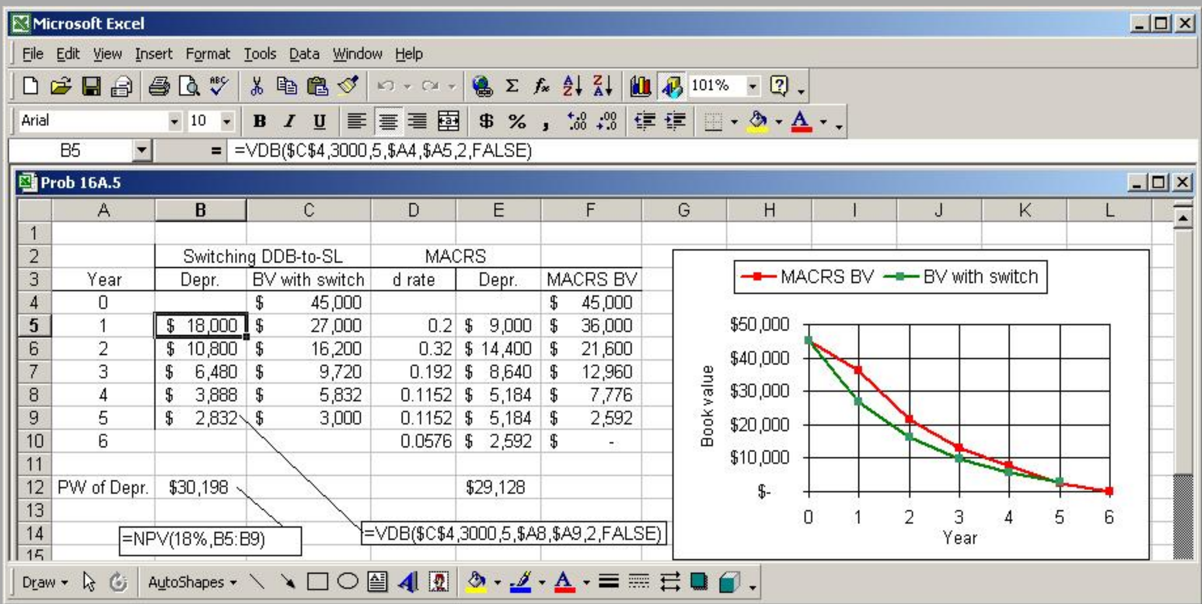
*BV_5 will be \$3000 exactly when SL depreciation of \$2832 is applied in year 5.

$$BV_5 = 5832 - 2832 = \$3000$$

The switch to SL occurs in year 5 and the PW of depreciation is:

$$PW_D = 18{,}000(P/F,18\%,1) + \ldots + 2{,}832(P/F,18\%,5) \;= \$30{,}198$$

16A.5 Develop a spreadsheet for the DDB-to-SL switch using the VDB function (column B) and MACRS values plus the PW_D for both methods.



	Switching DDB-to-SL		MACRS		
Year	Depr.	BV with switch	d rate	Depr.	MACRS BV
0		\$ 45,000			\$ 45,000
1	\$ 18,000	\$ 27,000	0.2	\$ 9,000	\$ 36,000
2	\$ 10,800	\$ 16,200	0.32	\$ 14,400	\$ 21,600
3	\$ 6,480	\$ 9,720	0.192	\$ 8,640	\$ 12,960
4	\$ 3,888	\$ 5,832	0.1152	\$ 5,184	\$ 7,776
5	\$ 2,832	\$ 3,000	0.1152	\$ 5,184	\$ 2,592
6			0.0576	\$ 2,592	\$ -
PW of Depr.	\$30,198			\$29,128	

Were switching allowed in the USA, it would give only a slightly higher PW_D = \$30,198 compared to the value for MACRS of PW_D = \$29,128.

16A.6 175% DB: $d = \frac{1.75}{10} = 0.175$ for t = 1 to 5 $BV_t = 110{,}000(0.825)^t$

SL: $D_t = \frac{BV_5 - 10{,}000}{5} = (42{,}040 - 10{,}000)/5 = \$6408$ for t = 6 to 10

$BV = BV_5 - t(6408)$

PW_D = \$64,210 from Column D using the NPV function.

Microsoft Excel

Prob 16A.6

D16 = =NPV(12%,B5:B9)+NPV(12%,C5:C14)

	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.7 (a) Use Equation [16A.6] for DDB with d = 2/25 = 0.08.

$BV_{25} = 155{,}000(1 - 0.08)^{25} = \$19{,}276.46 < \$50{,}000$

No, the switch should not be made.

(b) $155{,}000(1-d)^{25} > 50{,}000$ $1 - d > [50{,}000/155{,}000]^{1/25}$ $1 - d > (0.3226)^{0.04} = 0.95575$

$d < 1 - 0.95575 = 0.04425$

If d < 0.04425 the switch is advantageous. This is approximately 50% of the current DDB rate of 0.08. The SL rate would be d = 1/25 = 0.04.

16A.8 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.14] for DDB:

$d_{DB,\,2} = 0.4(1 - 0.2) = 0.32$ (Selected)

By Eq. [16A.15] for SL:

$d_{SL,\,2} = 0.8/4.5 = 0.178$

d_3: For DDB

$d_{DB,\,3} = 0.4(1 - 0.2 - 0.32)$
$= 0.192$ (Selected)

For SL
$d_{SL,\,2} = 0.48/3.5 = 0.137$

d_4: $d_{DB,\,4} = 0.4(1 - 0.2 - 0.32 - 0.192)$
$= 0.1152$
$d_{SL,\,4} = 0.288/2.5 = 0.1152$ (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.9 $B = \$30,000$ $n = 5$ years $d = 0.40$

Find BV_3 using d_t rates derived from Equations [16A.10] through [16A.12].

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.11]

$d = 0.4$

$D_{DB} = 0.4(24,000)$

$= \$9600$

$BV_2 = 24,000 – 9600 = \$14,400$

For SL, if switch is better, in year 2, by Eq. [16A.12].

$$D_{SL} = \frac{24,000}{5–2+1.5} = \$5333$$

Select DDB; it is larger.

t = 3: For DDB, apply Eq. [16A.11] again.

$D_{DB} = 14,400(0.4) = \$5760$

$BV_3 = 14,400 – 5760 = \$8640$

For SL, Eq. [16A.12]

$$D_S = \frac{14,400}{5–3+1.5} = \$4114$$

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.10 Determine MACRS depreciation for n = 7 using Equations [16A.10] through [16A.12]. and apply them to B = \$50,000. (S) indicates the selected method and amount.

	DDB	SL
t = 1:	$d = 1/7 = 0.143$ $D_{DB} = \$7150$ (S) $BV_1 = \$42{,}850$	$D_{SL} = 0.5(1/7)(50{,}000)$ $= \$3571$
t = 2:	$d = 2/7 = 0.286$ $D_{DB} = \$12{,}255$ (S) $BV_2 = \$30{,}595$	$D_{SL} = \dfrac{42{,}850}{7-2+1.5} = \$6592$
t = 3:	$d = 0.286$ $D_{DB} = \$8750$ (S) $BV_3 = \$21{,}845$	$D_{SL} = \dfrac{30{,}595}{7-3+1.5} = \$5563$
t = 4:	$d = 0.286$ $D_{DB} = \$6248$ (S) $BV_4 = 15{,}597$	$D_{SL} = \dfrac{21{,}845}{7-4+1.5} = \$4854$
t = 5:	$d = 0.286$ $D_{DB} = \$4461$ (S) $BV_5 = \$11{,}136$	$D_{SL} = \dfrac{15{,}597}{7-5+1.5} = \$4456$
t = 6:	$d = 0.286$ $D_{DB} = \$3185$ (Use SL hereafter)	$D_{SL} = \dfrac{11{,}136}{7-6+1.5} = \$4454$ (S) $BV_6 = \$6682$
t = 7:		$D_{SL} = \dfrac{6682}{7-7+1.5} = \$4454$ $BV_7 = \$2228$
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.11 (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.

Chapter 17

After-Tax Economic Analysis

Solutions to Problems

17.1 TI = GI – E – D
NPAT = (GI – E – D)(1 – T)

17.2 Income tax for an individual is based on the amount of money received from a salary for a job, contract for services rendered, and the like. Property tax is based on the appraised worth of things owned, such as house, car, and personal possessions like jewelry, art, etc.

17.3 (a) Net profit after taxes
(b) Taxable income
(c) Depreciation
(d) Operating expense
(e) Taxable income

17.4 (a) Company 1

TI = Gross income - Expenses - Depreciation
= (1,500,000 + 31,000) – 754,000 – 148,000
= $629,000

Taxes = 113,900 + 0.34(629,000 – 335,000)
= $213,860

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) Co. 1: 213,860/1.5 million = 14.26%
Co. 2: 75,290/820,000 = 9.2%

(c) Company 1

Taxes = (TI)(T_e) = 629,000(0.34) = $213,860
% error with graduated tax = 0%

Company 2

$\text{Taxes} = 236{,}000(0.34) = \$80{,}240$

$$\% \text{ error} = \frac{80{,}240 - 75{,}290}{75{,}290}(100\%) = +\ 6.6\%$$

17.5 Taxes using graduated rates:

$$\text{Taxes on } \$300{,}000\text{: } 22{,}250 + 0.39(200{,}000) = \$100{,}250$$

(a) Average tax rate = 100,250/300,000 = 34.0%

(b) 34% from Table 17.1

(c) Taxes = 113,900 + 0.34(165,000) = \$170,000
Average tax rate = 170,000/500,000 = 34.0%

(d) Marginal rate is 39% for \$35,000 and 34% for \$165,000. Use Eq. [17.3].
NPAT = 200,000 – 0.39(35,000) – 0.34(165,000) = \$130,250

17.6 $T_e = 0.076 + (1 - 0.076)(0.34) = 0.390$
TI = 6.5 million – 4.1 million = \$2.4 million
Taxes =2,400,000(0.390) = \$936,000

17.7 (a) $T_e = 0.06 + (1 - 0.6)(0.23) = 0.2762$

(b) Reduced $T_e = 0.9(0.2762) = 0.2486$

Set x = required state rate

$0.2486 = x + (1\text{-}x)(0.23)$

$x = 0.0186/0.77 = 0.0242 \quad (2.42\%)$

(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.

17.8 (a) Federal taxes = 13,750 + 0.34(5000) = \$15,450 (using Table 17-1 rates)

Average federal rate = (15,450/80,000)(100%)

= 19.3%

(b) Effective tax rate $= 0.06 + (1 – 0.06)(0.193)$
$= 0.2414$

(c) Total taxes using effective rate = 80,000(0.2414) = \$19,314

(d) State: 80,000(0.06) = \$4800

Federal: 80,000[0.193(1 – 0.06)] = 80,000(0.1814) = \$14,514

17.9 (a) GI = 98,000 + 7500 = \$105,500
TI = 105,500 – 10,500 = \$95,000

Using the rates in Table 17-2:

$$\begin{aligned} \text{Taxes} &= 0.10(7000) + 0.15(28{,}400\text{-}7000) \\ &\quad + 0.25(68{,}800 – 28{,}400) + 0.28(95{,}000 – 68{,}800) \\ &= 0.10(7000) + 0.15(21{,}400) + 0.25(40{,}400) + 0.28(26{,}200) \\ &= \$21{,}346 \end{aligned}$$

(b) 21,346/98,000 = 21.8%

(c) Reduced taxes = 0.9(21,346) = \$19,211

From part (b), taxes are determined from the relation below where x = new TI.

$$\begin{aligned} \text{Taxes} = 19{,}211 &= 0.10(7000) + 0.15(21{,}400) + 0.25(40{,}400) + 0.28(\text{TI} – 26{,}200) \\ &= 700 + 3210 + 10{,}100 + 0.28(x – 68{,}800) \\ &= 14{,}010 + 0.28(x – 68{,}800) \end{aligned}$$

$$\begin{aligned} 0.28x &= 24{,}465 \\ x &= \$87{,}375 \end{aligned}$$

From part (a),set TI = \$87,375 and let y = new total of exemptions and deductions

$$\begin{aligned} \text{TI} = 87{,}375 &= 105{,}500 – y \\ y &= \$18{,}125 \end{aligned}$$

Total would have to increase from \$10,500 to \$18,125, which is a 73% increase. This is not likely to be possible.

17.10 NPAT = GI – E – D – taxes

CFAT = GI – E – P + S – taxes

Consideration of depreciation is a fundamental difference. The NPAT expression deducts depreciation outside the TI and tax computation. The CFAT expression removes the capital investment (or adds the salvage) but does not consider depreciation, since it is a noncash flow.

17.11 D = P = S = 0. From Equation [17.9] with tax rate = T

$$CFAT = GI - E - (GI - E)(T)$$

$$= (GI - E)(1 - T)$$

17.12 Depreciation is only used to find TI. Depreciation is not a true cash flow, and as such is not a direct reduction when determining either CFBT or CFAT for an alternative.

17.13 All values are times $10,000

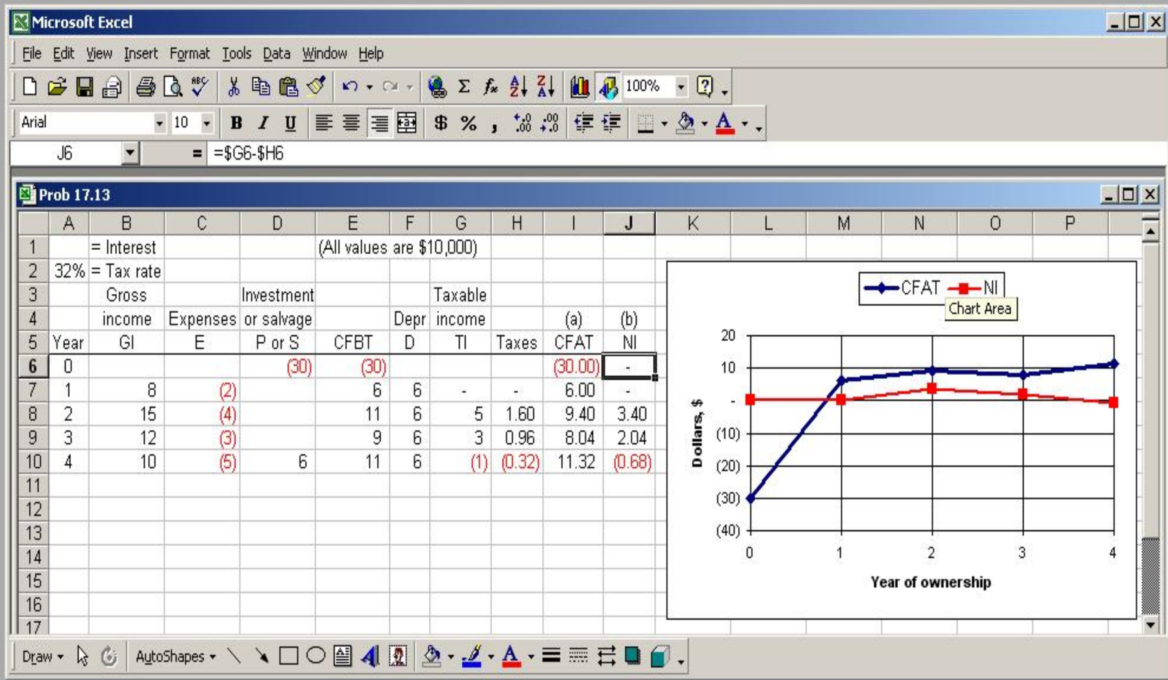
(a) CFAT = GI – E – P + S – taxes

(b) NPAT = TI – taxes

Year	GI	E	P or S	D	TI	Taxes	(a) CFAT	(b) NPAT
0	–	–	30	–	–	–	$-30.0	
1	8	2		6	0	0.0	6.0	0.0
2	15	4		6	5	1.6	9.4	3.4
3	12	3		6	3	0.96	8.04	2.04
4	10	5	6	6	-1	-0.32	11.32	-0.68

(c) Calculate CFAT and NI and plot them on one chart. Note the significant difference in the yearly values of CFAT and NI.

17.13 (cont)



J6 = =$G6-$H6

Prob 17.13

	A	B	C	D	E	F	G	H	I	J
1		= Interest			(All values are $10,000)					
2	32%	= Tax rate								
3		Gross		Investment			Taxable			
4		income	Expenses	or salvage		Depr	income		(a)	(b)
5	Year	GI	E	P or S	CFBT	D	TI	Taxes	CFAT	NI
6	0			(30)	(30)				(30.00)	-
7	1	8	(2)		6	6	-	-	6.00	-
8	2	15	(4)		11	6	5	1.60	9.40	3.40
9	3	12	(3)		9	6	3	0.96	8.04	2.04
10	4	10	(5)	6	11	6	(1)	(0.32)	11.32	(0.68)

17.14 MACRS rates with n = 3 are from Table 16-2. All numbers are times $10,000.

	Year	GI	P or S	E	D	TI	Taxes	(a) CFAT	(b) CFAT
	0	–	-20	–	–	–	–	-20.000	-20.000
	1	8		2	6.666	-.666	-.266	6.266	6.266
	2	15		4	8.890	2.110	.844	10.156	10.156
	3	12		3	2.962	6.038	2.415	6.585	6.585
(a)	4	10	0	5	1.482	3.518	1.407	3.593	–
(b)	4	10	2	5	1.482	3.518	1.407	–	5.593

The S = $20,000 in year 4 is $20,000 of positive cash flow. CFAT for years 0 through 3 are the same as for S = 0.

17.15 No capital purchase (P) or salvage (S) is involved.

$$\begin{aligned} CFBT &= CFAT + taxes \\ &= CFAT + TI(T_e) \\ &= CFAT + (GI - E - D)T_e \\ &= CFAT + (CFBT - D)T_e \end{aligned}$$

$$CFBT = [CFAT - D(T_e)]/(1 - T_e)$$

$$T_e = 0.045 + 0.955(0.35) = 0.37925$$

$$\begin{aligned} CFBT &= [2{,}000{,}000 - (1{,}000{,}000)(0.37925)]/(1 - 0.37925) \\ &= 1{,}620{,}750/0.62075 \\ &= \$2{,}610{,}955 \end{aligned}$$

17.16 (a) $T_e = 0.065 + (1 - 0.065)(0.35) = 0.39225$

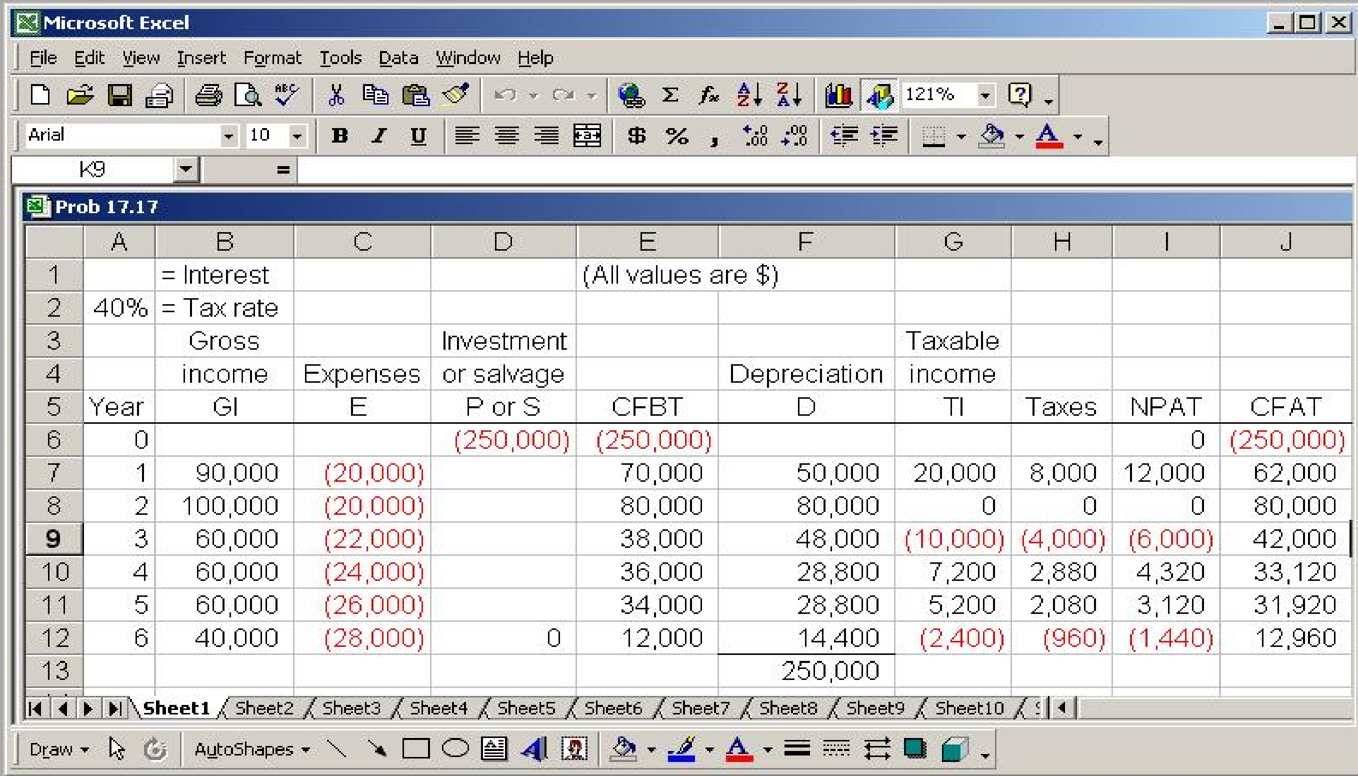
$$\begin{aligned} CFAT &= GI - E - TI(T_e) = 48 - 28 - (48\text{-}28\text{-}8.2)(0.39225) \\ &= 20 - 11.8(0.39225) \\ &= \$15.37 \text{ million} \end{aligned}$$

(b) Taxes = $(48 - 28 - 8.2)(0.39225) = \$4.628$ million

% of revenue = 4.628/48 = 9.64%

(c) $NI = TI(1 - T_e) = (48\text{-}28\text{-}8.2)(1 - 0.39225)$
$= \$7.17$ million

17.17 CFBT = GI – Expenses – Investment + Salvage
TI = CFBT – Depreciation
Taxes = 0.4(TI)
CFAT = CFBT – taxes
NPAT = TI – taxes



Prob 17.17

	A	B	C	D	E	F	G	H	I	J
1		= Interest			(All values are $)					
2	40%	= Tax rate								
3		Gross		Investment			Taxable			
4		income	Expenses	or salvage		Depreciation	income			
5	Year	GI	E	P or S	CFBT	D	TI	Taxes	NPAT	CFAT
6	0			(250,000)	(250,000)				0	(250,000)
7	1	90,000	(20,000)		70,000	50,000	20,000	8,000	12,000	62,000
8	2	100,000	(20,000)		80,000	80,000	0	0	0	80,000
9	3	60,000	(22,000)		38,000	48,000	(10,000)	(4,000)	(6,000)	42,000
10	4	60,000	(24,000)		36,000	28,800	7,200	2,880	4,320	33,120
11	5	60,000	(26,000)		34,000	28,800	5,200	2,080	3,120	31,920
12	6	40,000	(28,000)	0	12,000	14,400	(2,400)	(960)	(1,440)	12,960
13						250,000				

17.18 (a) Find BV_2 after 2 years of MACRS depreciation.

$$BV_2 = 80{,}000 - 16{,}000 - 25{,}600 = \$38{,}400$$

(b) Sell asset for $BV_2 = S = \$38{,}400$ and use CFAT = GI – E – P + S – Taxes

Year	(GI – E)	P or S	D	TI	Taxes	CFAT
0	-	–80,000	-	-	-	-$80,000
1	50,000		16,000	34,000	12,920	37,080
2	50,000	38,400	25,600	24,400	9,272	79,128

17.19 (a) For SL depreciation with n = 3 years, D_t = \$50,000 per year, Taxes = TI(0.35)

Year	CFBT	Depr	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	Depr	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	20,225
4	0	7.41	11,115	-11,115	-3,890

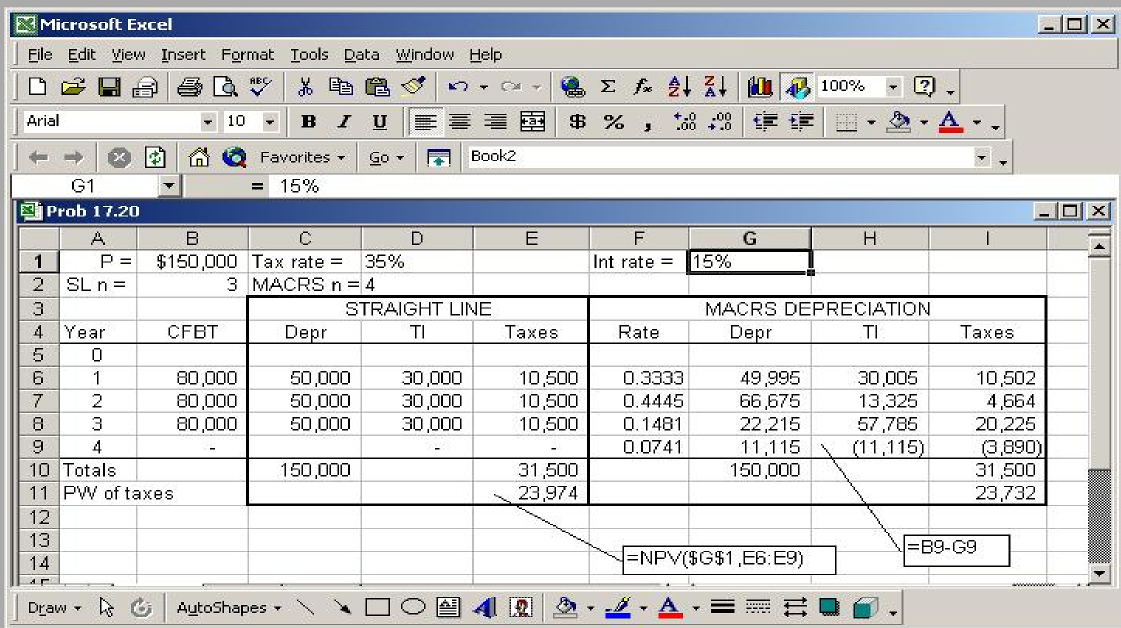
PW_{tax} = 10,502(P/F,15%,1) + ... - 3890(P/F,15%,4) = $23,733

MACRS has only a slightly lower PW_{tax} value.

(b) Total taxes: SL is 3(10,500) = $31,500

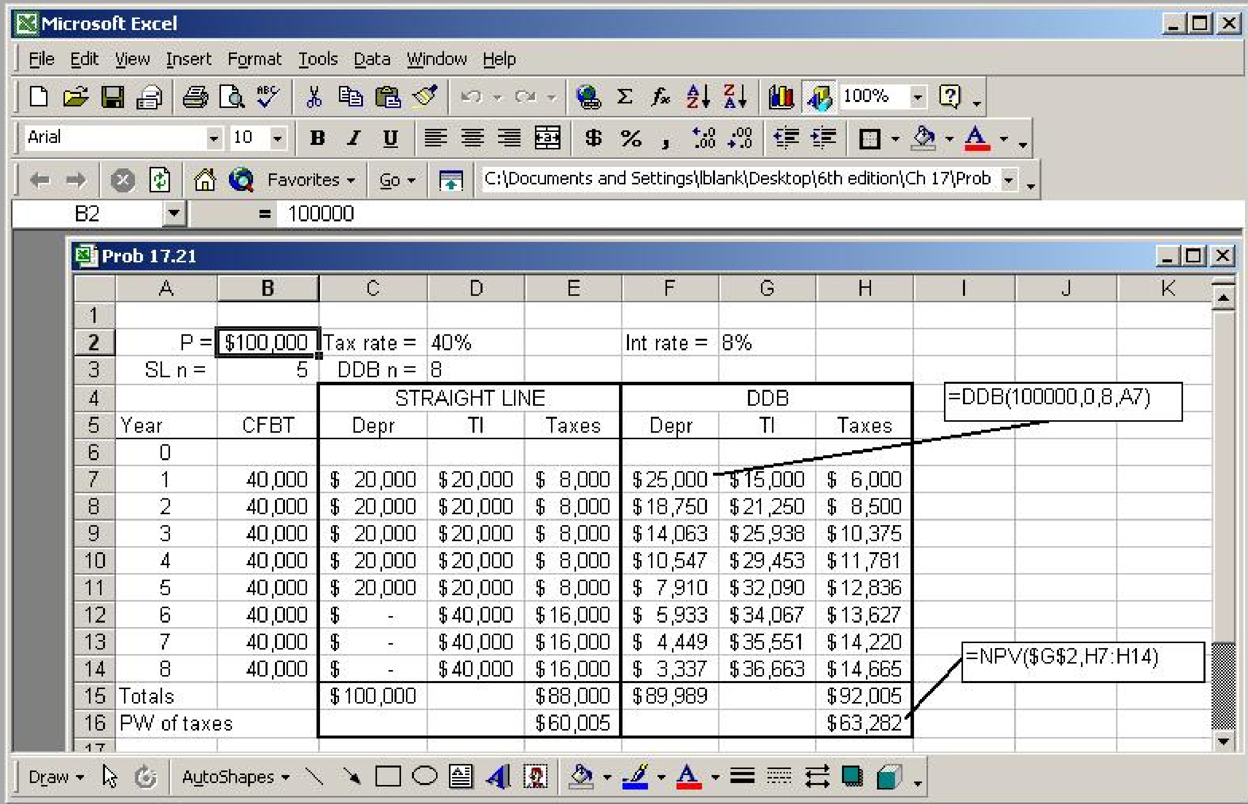
MACRS is 10,502 + … - 3890 = $31,501   (rounding error)

17.20 MACRS has only a slightly lower PW_{tax} value.



	A	B	C	D	E	F	G	H	I
1	P =	$150,000	Tax rate =	35%		Int rate =	15%		
2	SL n =	3	MACRS n =	4					
3			STRAIGHT LINE			MACRS DEPRECIATION			
4	Year	CFBT	Depr	TI	Taxes	Rate	Depr	TI	Taxes
5	0								
6	1	80,000	50,000	30,000	10,500	0.3333	49,995	30,005	10,502
7	2	80,000	50,000	30,000	10,500	0.4445	66,675	13,325	4,664
8	3	80,000	50,000	30,000	10,500	0.1481	22,215	57,785	20,225
9	4	-		-	-	0.0741	11,115	(11,115)	(3,890)
10	Totals		150,000		31,500		150,000		31,500
11	PW of taxes				23,974				23,732

17.21 Here Taxes = (CFBT – depr)(tax rate). Use NPV function for PW of taxes. Select the SL method with n = 5 years since it has the lower PW of tax.



Prob 17.21

B2 = 100000

	A	B	C	D	E	F	G	H
1								
2	P =	$100,000	Tax rate =	40%		Int rate =	8%	
3	SL n =	5	DDB n =	8				
4			STRAIGHT LINE			DDB		
5	Year	CFBT	Depr	TI	Taxes	Depr	TI	Taxes
6	0							
7	1	40,000	$ 20,000	$20,000	$ 8,000	$25,000	$15,000	$ 6,000
8	2	40,000	$ 20,000	$20,000	$ 8,000	$18,750	$21,250	$ 8,500
9	3	40,000	$ 20,000	$20,000	$ 8,000	$14,063	$25,938	$10,375
10	4	40,000	$ 20,000	$20,000	$ 8,000	$10,547	$29,453	$11,781
11	5	40,000	$ 20,000	$20,000	$ 8,000	$ 7,910	$32,090	$12,836
12	6	40,000	$ -	$40,000	$16,000	$ 5,933	$34,067	$13,627
13	7	40,000	$ -	$40,000	$16,000	$ 4,449	$35,551	$14,220
14	8	40,000	$ -	$40,000	$16,000	$ 3,337	$36,663	$14,665
15	Totals		$100,000		$88,000	$89,989		$92,005
16	PW of taxes				$60,005			$63,282

=DDB(100000,0,8,A7)

=NPV($G$2,H7:H14)

17.22 (a) U.S. Asset - MACRS

For each year, use D for MACRS with n = 5

TI = CFBT – D = 65,000 – D

Taxes = TI(0.4)

Year	d	Depr	TI	Taxes
1	0.20	$50,000	$15,000	$6000
2	0.32	80,000	-15,000	-6000
3	0.192	48,000	17,000	6800
4	0.1152	28,800	36,200	14,480
5	0.1152	28,800	36,200	14,480
6	0.0576	14,400	50,600	20,240
				$56,000

PW_{tax} = 6000(P/F,12%,1) - ... + 20,240(P/F,12%,6)

= $33,086

Italian Asset - Classical SL

Calculate SL depreciation with n = 5 and find TI for all 6 years.

$D = (250{,}000 - 25{,}000)/5 = \$45{,}000$

$TI = 65{,}000 - 45{,}000 = \$20{,}000$

Year	D	TI	Taxes
1	$45,000	20,000	$8000
2	45,000	20,000	8000
3	45,000	20,000	8000
4	45,000	20,000	8000
5	45,000	20,000	8000
6	0	65,000	26,000
			$66,000

$PW_{tax} = 8000(P/A,12\%,5) + 26{,}000(P/F,12\%,6) = \$42{,}010$

As expected, MACRS has a smaller PW_{tax}

(b) Total taxes are $56,000 for MACRS and $66,000 for classical SL. The SL depreciation has S = $25,000, so a total of (25,000)(0.4) more in taxes is paid. This generates the $10,000 difference in total taxes. (Also, there are no taxes included on the depreciation recapture of $25,000 in year 6.)

17.23 Find the difference between PW of CFBT and CFAT.

Year	CFBT	d	Depr	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

$PW_{CFBT} = 10{,}000(P/A,10\%,4) + 5000(P/A,10\%,2)(P/F,10\%,4) = \$37{,}626$

$PW_{CFAT} = 6720(P/F,10\%,1) + \ldots + 3207(P/F,10\%,6) = \$25{,}359$

Cash flow lost to taxes is $12,267 in PW dollars.

17.24 (a)

$$PW_{TS} = \sum_{t=1}^{t=n} (\text{tax savings in year t})(P/F,i,t)$$

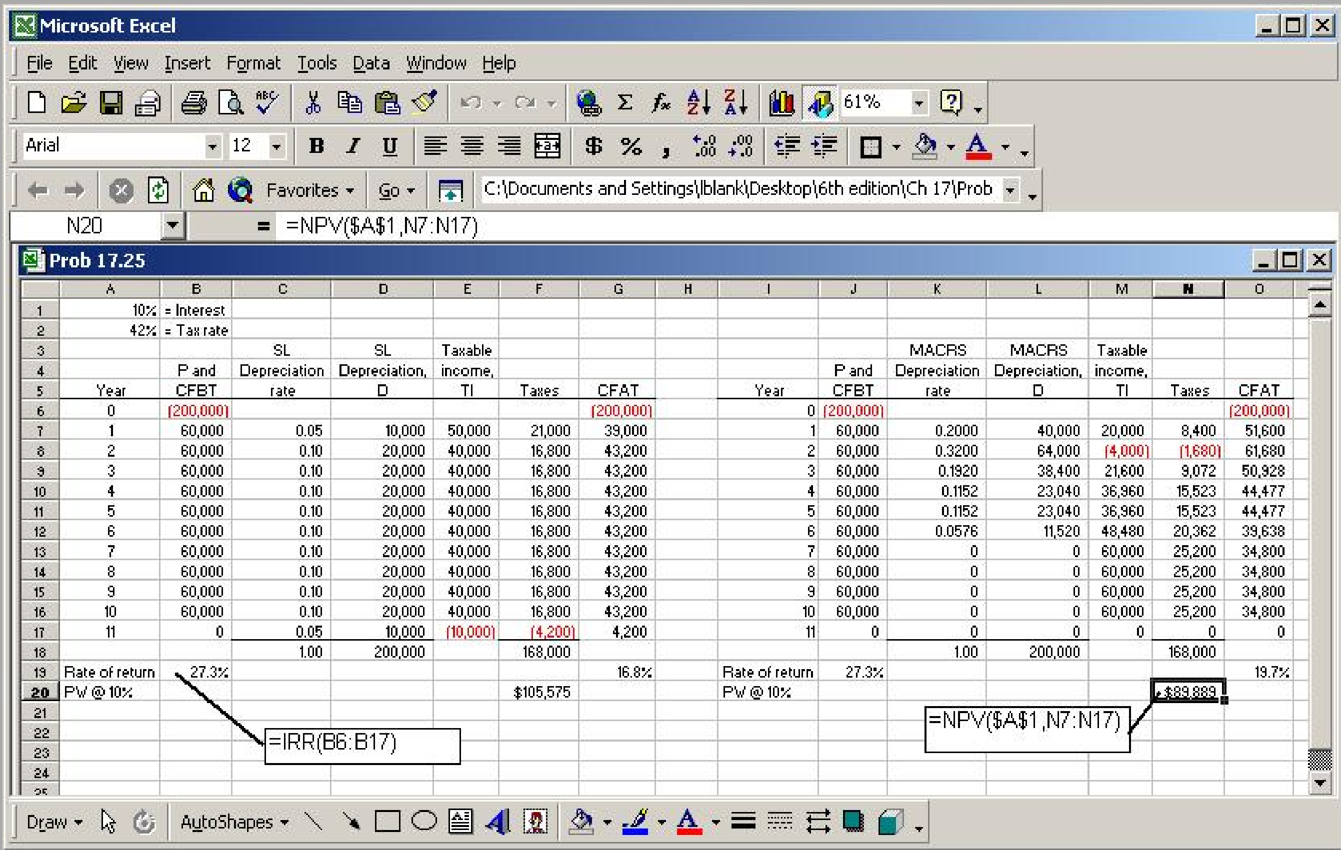
Select the method that maximizes PW_{TS}. This is the opposite of minimizing the PW_{tax} value, but the decision will be identical.

(b) $TS_t = D_t(0.42)$

Year,t	d	Depr	TS
1	0.3333	$26,664	$11,199
2	0.4445	35,560	14,935
3	0.1481	11,848	4,976
4	0.0741	5,928	2,490

PW_{TS} = 11,199(P/F,10%,1) + ...+ 2,490(P/F,10%,4) = $27,963

17.25


Microsoft Excel

N20 = =NPV($A$1,N7:N17)

Prob 17.25

	A	B	C	D	E	F	G
1	10%	= Interest					
2	42%	= Tax rate					
3			SL	SL	Taxable		
4		P and	Depreciation	Depreciation,	income,		
5	Year	CFBT	rate	D	TI	Taxes	CFAT
6	0	(200,000)					(200,000)
7	1	60,000	0.05	10,000	50,000	21,000	39,000
8	2	60,000	0.10	20,000	40,000	16,800	43,200
9	3	60,000	0.10	20,000	40,000	16,800	43,200
10	4	60,000	0.10	20,000	40,000	16,800	43,200
11	5	60,000	0.10	20,000	40,000	16,800	43,200
12	6	60,000	0.10	20,000	40,000	16,800	43,200
13	7	60,000	0.10	20,000	40,000	16,800	43,200
14	8	60,000	0.10	20,000	40,000	16,800	43,200
15	9	60,000	0.10	20,000	40,000	16,800	43,200
16	10	60,000	0.10	20,000	40,000	16,800	43,200
17	11	0	0.05	10,000	(10,000)	(4,200)	4,200
18			1.00	200,000		168,000	
19	Rate of return	27.3%					16.8%
20	PW @ 10%					$105,575	

	I	J	K	L	M	N	O
3			MACRS	MACRS	Taxable		
4		P and	Depreciation	Depreciation,	income,		
5	Year	CFBT	rate	D	TI	Taxes	CFAT
6	0	(200,000)					(200,000)
7	1	60,000	0.2000	40,000	20,000	8,400	51,600
8	2	60,000	0.3200	64,000	(4,000)	(1,680)	61,680
9	3	60,000	0.1920	38,400	21,600	9,072	50,928
10	4	60,000	0.1152	23,040	36,960	15,523	44,477
11	5	60,000	0.1152	23,040	36,960	15,523	44,477
12	6	60,000	0.0576	11,520	48,480	20,362	39,638
13	7	60,000	0	0	60,000	25,200	34,800
14	8	60,000	0	0	60,000	25,200	34,800
15	9	60,000	0	0	60,000	25,200	34,800
16	10	60,000	0	0	60,000	25,200	34,800
17	11	0	0	0	0	0	0
18			1.00	200,000		168,000	
19	Rate of return	27.3%					19.7%
20	PW @ 10%					$89,889	

=IRR(B6:B17)

=NPV($A$1,N7:N17)

(a and b)

	SL	MACRS
i* of CFBT	27.3%	27.3%
i* of CFAT	16.8%	19.7%

MACRS raises the after tax i* because of accelerated depreciation.

(c) Select MACRS with PW_{tax} = \$89,889 versus \$105,575 for SL.

17.26 1. Since land does not depreciate,

CG = TI = 0.15(2.6 million) = \$390,000
Taxes = 390,000(0.30) = \$117,000

2. SP = \$10,000
BV_5 = 155,000(0.0576) = \$8928
DR = SP – BV_5 = \$1072
Taxes = DR(T_e) = 1072(0.30) = \$322

3. SP = 0.2(150,000) = \$30,000
BV_7 = \$0
DR = SP – BV_7 = \$30,000
Taxes = 30,000(0.3) = \$9000

17.27 1. CL = 5000 – 500 = \$4500
TI = \$–4500
Tax savings = 0.40(–4500) = \$–1800

2. CG = \$10,000
DR = 0.2(100,000) = \$20,000
TI = CG + DR = \$30,000
Taxes = 30,000(0.4) = \$12,000

17.28 (a) The relations used in year 6 for DR and CFAT are taken from Equations [17.12] and [17.9] respectively.

DR = SP – BV_6 = 500 – (10,000 – sum depr. or 6 years)
CFAT = (GI-E) + SP – taxes

(b) Conclusion is that the total CFAT of \$12,710 is the same for both; only the timing is different.

n = 5 P = $10,000 S = $500 Tax rate = 38%

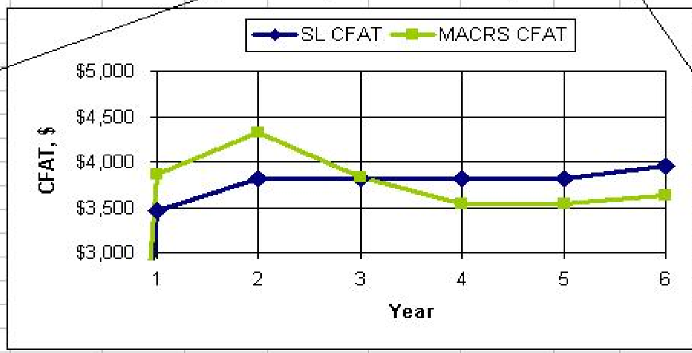
			Straight line with half-year convention					MACRS Depreciation					
Year	GI - E	P or S	Depr	DR	TI	Taxes	SL CFAT	Depr rate	Depr	DR	TI	Taxes	MACRS CFAT
0	$ -	$ (10,000)			$ -	$ -	$ (10,000)				$ -	$ -	$ (10,000)
1	$5,000		$ 950		$4,050	$1,539	$ 3,461	0.2000	$ 2,000		$ 3,000	$ 1,140	$ 3,860
2	$5,000		$ 1,900		$3,100	$1,178	$ 3,822	0.3200	$ 3,200		$ 1,800	$ 684	$ 4,316
3	$5,000		$ 1,900		$3,100	$1,178	$ 3,822	0.1920	$ 1,920		$ 3,080	$ 1,170	$ 3,830
4	$5,000		$ 1,900		$3,100	$1,178	$ 3,822	0.1152	$ 1,152		$ 3,848	$ 1,462	$ 3,538
5	$5,000		$ 1,900		$3,100	$1,178	$ 3,822	0.1152	$ 1,152		$ 3,848	$ 1,462	$ 3,538
6	$5,000	$ 500	$ 950	$ -	$4,050	$1,539	$ 3,961	0.0576	$ 576	$500	$ 4,924	$ 1,871	$ 3,629
Total			$ 9,500				$ 12,710		$10,000				$ 12,710

=SLN(10000,500,5)/2

=$B13+$C13-G13

=$B13-J13+K13

=$C$13 - ($D$3-SUM(J$8:J$13))



17.29 (a) Use MACRS rates for n = 5

BV_2 = 40,000 - 0.52(40,000) = $19,200

There is depreciation recapture (DR)

DR = 21,000 – 19,200 = $1800

TI = GI – E – D + DR

= 20,000 – 3000 – 0.32(40,000) + 1800 = $6,000

Taxes = 6,000(0.35) = $2100

(b) CFAT = GI – E + SP – taxes

= 20,000 – 3000 + 21,000 – 2100

= $35,900

17.30 Land: CG = \$45,000
Building: CL = \$45,000
Cleaner: DR = 18,500 – 15,500 = \$3000
Circulator: DR = 10,000 - 5,000 = \$5,000
CG = 10,500 - 10,000 = \$500

17.31 In year 4, DR = \$20,000 as additional TI.
In \$10,000 units, at the time of sale in year 4:

Year	GI	E	SP	D	TI	Taxes	CFAT
4	\$10	\$5	\$2	\$1.482	\$5.518	2.2072	\$4.7928

CFAT = GI – E + SP – taxes
= 10 – 5 + 2 – 2.2072
= \$4.7928 (\$47,928)

CFAT decreased from \$55,930 as calculated in Prob.17.14(b).

17.32 <u>Straight line depreciation</u>

$$D_t = \frac{45{,}000 - 3000}{5} = \$8400$$

TI = 15,000 – 8400 = \$6600
Taxes = 6600(0.5) = \$3300
No depreciation recapture is involved.

PW_{tax} = 3300(P/A,18%,5) = \$10,320

<u>DDB-to-SL switch</u>

TI = 15,000 – D_t
Taxes = TI(0.50)

The depreciation schedule was determined in Problem 16A.4.

t	CFBT	Depr	Method	TI	Taxes
1	\$15,000	18,000	DDB	\$–3000	\$–1500
2	15,000	10,800	DDB	4200	2100
3	15,000	6480	DDB	8520	4260
4	15,000	3888	DDB	11,112	5556
5	15,000	2832	SL	12,168	6084

$$PW_{tax} = -1500(P/F,18\%,1) + ... + 6084(P/F,18\%,5)$$
$$= \$8355$$

Switching gives a \$1965 lower PW_{tax} value.

17.33 Chapter 4 includes a description of the method used to determine each of the following:

Net short-term capital gain or loss
Net long-term capital gain or loss
Net gain
Net loss

In brief, net all short term, then all long term gains and losses. Finally, net the gains and losses to determine what is reported on the return and how it is taxed.

17.34 Effective tax rate = 0.06 + (1 – 0.06) (0.35)
= 0.389

$$\text{Before-tax ROR} = \frac{0.09}{1 - 0.389}$$
$$= 0.147$$

A 14.7 % before-tax rate is equivalent to 9% after taxes.

17.35 Calculate taxes using Table 17-1 rates, use Equations [17.4] for the average tax rate and [17.5] for T_e, followed by Equation [17.17] solved for after-tax ROR.

Income taxes = 113,900 + 0.34(8,950.000-335,000)
= 113,900 + 2,929,100
= \$3,043,000

Average tax rate = taxes /TI = 3,043,000/8,950,000
= 0.34

$$T_e = 0.05 + (1-0.05)(0.34) = 0.373$$

After-tax ROR = (before-tax ROR)(1-T_e)
= 0.22(1 – 0.373)
= 0.138

A before-tax ROR of 22% is equivalent to an after-tax ROR of 13.8%

17.36 $$0.08 = 0.12\,(1\text{-tax rate})$$
$$1\text{-tax rate} = 0.667$$
$$\text{Tax rate} = 0.333 \qquad (33.3\%)$$

17.37

Microsoft Excel

K15 = =IRR(K6:K14)

Prob 17.37

	A	B	C	D	E	F	G	H	I	J	K
1		= Interest									
2	30%	= Tax rate									
3		Gross		Investment					Taxable		
4		income,	Expenses,	& salvage,		Depr.	Depr.,	Bookvalue,	income,		
5	Year	GI	E	P and S	CFBT	rate	D	BV	TI(1)	Taxes	CFAT(2)
6	0			(3,500,000)	(3,500,000)			3,500,000			(3,500,000)
7	1	480,000	(100,000)	0	380,000	0.05	175,000	3,325,000	205,000	61,500	318,500
8	2	480,000	(100,000)	0	380,000	0.05	175,000	3,150,000	205,000	61,500	318,500
9	3	480,000	(100,000)	0	380,000	0.05	175,000	2,975,000	205,000	61,500	318,500
10	4	480,000	(100,000)	0	380,000	0.05	175,000	2,800,000	205,000	61,500	318,500
11	5	480,000	(100,000)	0	380,000	0.05	175,000	2,625,000	205,000	61,500	318,500
12	6	480,000	(100,000)	0	380,000	0.05	175,000	2,450,000	205,000	61,500	318,500
13	7	480,000	(100,000)	0	380,000	0.05	175,000	2,275,000	205,000	61,500	318,500
14	8	480,000	(100,000)	4,050,000	4,430,000	0.05	175,000	2,100,000	2,155,000	646,500	3,783,500
15				Rate of return =	12.1%					Rate of return =	9.0%
16											
17							(1) In year 8, TI = GI +E - D + (SP-P) + (P-BV)				
18							(2) In year 8, CFAT = GI + E + S - taxes				
19											

=$B14+$C14+$D14-$J14

Sheet1 / Sheet2 / Sheet3 / Sheet4 / Sheet5 / Sheet6 / Sheet7 / Sheet8 / Sheet9 / Sh

(a) CFAT is in column K.

(b) Before-tax ROR = 12.1% (cell E15)
After-tax ROR = 9.0% (cell K15)

17.38

	Cell	Before-tax	Cell	After-tax
PW:	B12	=-PV(14%,5,75000,15000)-200000	C12	=NPV(9%,C6:C10)+C5
AW:	B13	=PMT(14%,5,-B12)	C13	=PMT(9%,5,-C12)
ROR:	B14	=IRR(B5:B10)	C14	=IRR(C5:C10)

17.39 NE has an investment requirement now, so the incremental ROR is based on (NE-TSE) analysis. The original purchase prices four years ago do not enter into this after-tax analysis. The last 4 years of the MACRS rates are used to determine annual depreciation. Also, income taxes must be zero if the tax amount is negative. Solution uses the Excel IF statement for this logic.

Since MARR = 25% exceeds delta i* = 17.26%, the incremental investment is not justified. So, sell NE now, retain TSE for the 4 years and then dispose of it. The NPV function at varying i values verifies this. For example, at MARR = 25%, TSE has a larger PW value.

Prob 17.39

Tax rate = 35%

North Enterprises (NE)

Capital cost $ 10,000

Year	Investment	Revenue	Expenses	MACRS rate	Depr	TI	Taxes	CFAT
now	-500	0	0			0	0	-500
1		2000	500	0.0893	893	607	212	1288
2		2500	800	0.0892	892	808	283	1417
3		3000	1100	0.0893	893	1007	352	1548
4		3500	1400	0.0446	446	1654	579	1521

The Southern Exchange (TSE)

Capital cost $ 20,000

Year	Investment	Revenue	Expenses	MACRS rate	Depr	TI	Taxes	CFAT	Incr CFAT (NE-TSE)
now	0	0	0			0	0	0	-500
1		4000	800	0.0893	1786	1414	495	2705	-1418
2		3000	1200	0.0892	1784	16	6	1794	-377
3		2000	1500	0.0893	1786	-1286	0	500	1048
4		1000	2000	0.0446	892	-1892	0	-1000	2521
Breakeven	IRR								**17.26%**

PW values

i	NE	TSE
10%	$4,043	$3,635
15%	$3,578	$3,466
17.26%	$3,393	$3,393
20%	$3,186	$3,307
25%	$2,852	$3,159
30%	$2,566	$3,020
35%	$2,318	$2,891

=$I9-$I19

=IF(($G19*$J$1)>0,$G19*$J$1,0)

=IRR(J15:J19

17.40 (a) Solution by Computer -- Use the spreadsheet format of Figure 17-3b plus a column for BV.

Conclusion: PW_A = \$3345 and PW_B = \$9221. Select machine B.

(b) Solution by hand – Develop two tables similar to the spreadsheet.

Prob 17.40

40% = Tax rate; 8% = Interest

Machine A

Year	CFBT	Investment & salvage, P and S	Depreciation rate	Depreciation, D	Book value, BV	Taxable income, TI	Taxes	CFAT
0		(35,500)			35,500			(35,500)
1	8,000		0.2000	7,100	28,400	900	360	7,640
2	8,000		0.3200	11,360	17,040	(3,360)	(1,344)	9,344
3	8,000		0.1920	6,816	10,224	1,184	474	7,526
4	8,000		0.1152	4,090	6,134	3,910	1,564	6,436
5	8,000		0.1152	4,090	2,045	3,910	1,564	6,436
6	8,000		0.0576	2,045	0	5,955	2,382	5,618
7	8,000	4,000	0	0	0	8,000	3,200	8,800
			1	35,500				
							PW(A) =	$3,345

Machine B

Year	CFBT	Investment & salvage, P and S	Depreciation rate	Depreciation, D	Book value, BV	Taxable income, TI	Taxes	CFAT
0		(19,000)			19,000			(19,000)
1	6,500		0.2000	3,800	15,200	2,700	1,080	5,420
2	6,500		0.3200	6,080	9,120	420	168	6,332
3	6,500		0.1920	3,648	5,472	2,852	1,141	5,359
4	6,500		0.1152	2,189	3,283	4,311	1,724	4,776
5	6,500		0.1152	2,189	1,094	4,311	1,724	4,776
6	6,500		0.0576	1,094	0	5,406	2,162	4,338
7	6,500	3,000	0	0	0	6,500	2,600	6,900
			1	19,000				
							PW(B) =	$ 9,221

17.41 Both solutions are on the spreadsheet below.

Prob 17.41

	A	B	C	D	E	F	G	H	I	J	K	L
1				(a)			Before taxes					
2					Year	X	Y	Y - X				
3					0	-12000	-25000	-13000				
4					1	-3000	-1500	1500				
5					2	-3000	-1500	1500				
6					3	-3000	-1500	1500				
7					4	-3000	-1500	1500				
8					5	-3000	-1500	1500				
9					6	-3000	-1500	1500				
10					7	-3000	-1500	1500				
11					8	-3000	-1500	1500				
12					9	-3000	-1500	1500				
13					10	0	3500	3500				
14					Incr IRR			**4.72%**	=NPV($H$14,H4:H13)+H3			
15					PW	$ (26,839)	$ (31,475)	($0.00)				
16	(b)	After taxes										
17		**Alternative X**					**Alternative Y**					Incr CFAT
18	Year	CFBT	Depr	TI	Taxes	CFAT	CFBT	Depr	TI	Taxes	CFAT	(Y - X)
19	0	-12000				-12000	-25000				-25000	-13000
20	1	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
21	2	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
22	3	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
23	4	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
24	5	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
25	6	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
26	7	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
27	8	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
28	9	-3000	900	-3900	-1950	-1050	-1500	2,000	-3500	-1750	250	1300
29	10	0	900	-900	-450	450	3500	2,000	1500	750	2750	2300
30	Incr IRR											**1.29%**
31	PW @ 7%					$ (18,612)		=NPV(7%,K20:K29)+K19			$ (21,973)	

(a) The before-tax MARR equivalent is 7%/(1- 0.50) = 14% per year. The incremental ROR analysis uses (Y – X) since Y has a larger first cost.

Conclusion: Select X. Increment for Y not justified at MARR = 14% since incremental i* = 4.72%

(b) SL depreciation is

SL_X = (12,000 – 3,000)/10 = $ 900 per year

SL_Y = (25,000 – 5,000)/10 = $2000 per year

Conclusion: Select X. Increment for Y not justified at after-tax MARR = 7%
Since incremental i* = 1.29%.

17.42 (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.

Machine A

Annual depreciation = (15,000 – 3,000)/10 = \$1200
Tax savings = (AOC + D)0.5 = 4200(0.5) = \$2100
CFAT = –3000 + 2100 = \$–900

$PW_A = –15,000 – 900(P/A,7\%,10) + 3000(P/F,7\%,10)$
$= –15,000 – 900(7.0236) + 3000(0.5083)$
$= \$–19,796$

Machine B

$$\text{Annual depreciation} = \frac{22,000 – 5000}{10} = \$1700$$

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.

17.42 (cont)

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

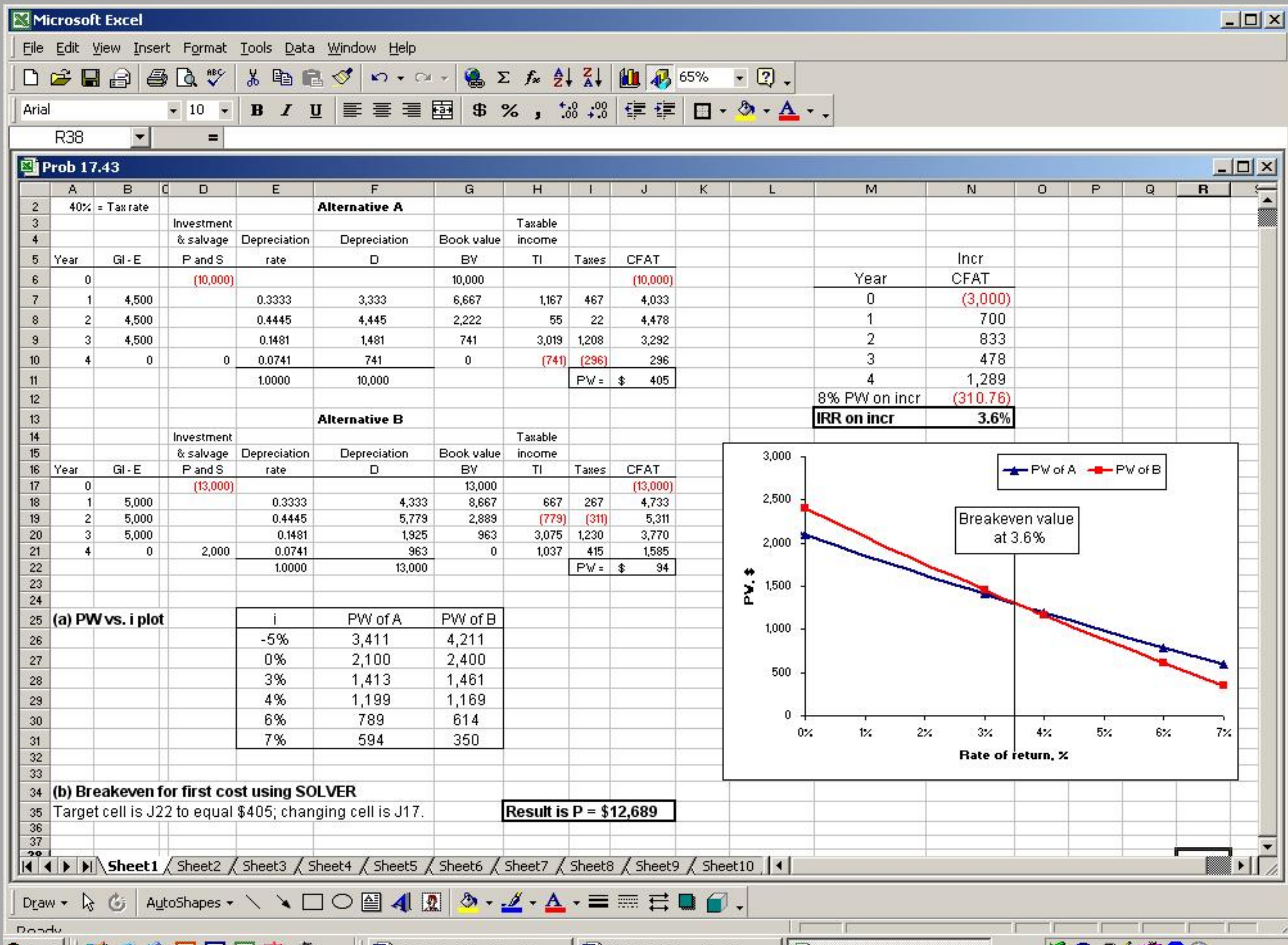
Year 10 has a DR tax of 5,000(0.5) = $2,500

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.

17.43 (a) incremental i = 3.6% (b) P = $12,689



40% = Tax rate

Alternative A

Year	GI - E	Investment & salvage P and S	Depreciation rate	Depreciation D	Book value BV	Taxable income TI	Taxes	CFAT
0		(10,000)			10,000			(10,000)
1	4,500		0.3333	3,333	6,667	1,167	467	4,033
2	4,500		0.4445	4,445	2,222	55	22	4,478
3	4,500		0.1481	1,481	741	3,019	1,208	3,292
4	0	0	0.0741	741	0	(741)	(296)	296
			1.0000	10,000			PW =	$ 405

Alternative B

Year	GI - E	Investment & salvage P and S	Depreciation rate	Depreciation D	Book value BV	Taxable income TI	Taxes	CFAT
0		(13,000)			13,000			(13,000)
1	5,000		0.3333	4,333	8,667	667	267	4,733
2	5,000		0.4445	5,779	2,889	(779)	(311)	5,311
3	5,000		0.1481	1,925	963	3,075	1,230	3,770
4	0	2,000	0.0741	963	0	1,037	415	1,585
			1.0000	13,000			PW =	$ 94

Year	Incr CFAT
0	(3,000)
1	700
2	833
3	478
4	1,289
8% PW on incr	(310.76)
IRR on incr	**3.6%**

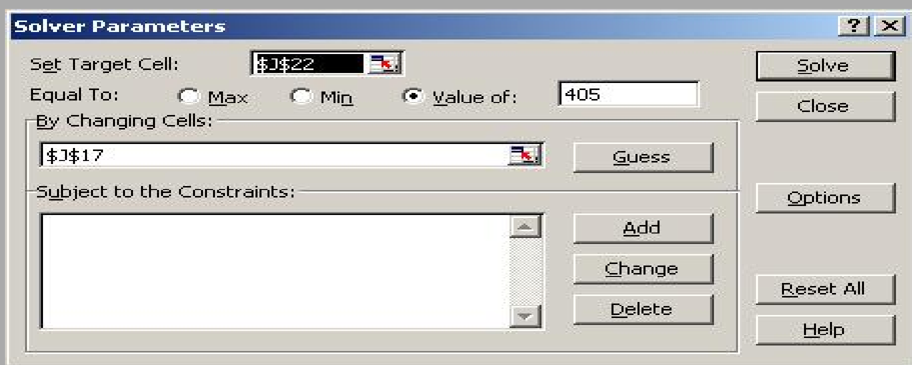
(a) PW vs. i plot

i	PW of A	PW of B
-5%	3,411	4,211
0%	2,100	2,400
3%	1,413	1,461
4%	1,199	1,169
6%	789	614
7%	594	350

(b) Breakeven for first cost using SOLVER

Target cell is J22 to equal $405; changing cell is J17.

Result is P = $12,689



17.44 System A

Depreciation = 150,000/3 = $50,000

For years 1 to 3:

$$TI = 60,000 – 50,000 = \$10,000$$
$$Taxes = 10,000(0.35) = \$3500$$
$$CFAT = 60,000 – 3500 = \$56,500$$

$$\begin{aligned} AW_A &= –150,000(A/P,6\%,3) + 56,500 \\ &= –150,000(0.37411) + 56,500 \\ &= \$384 \end{aligned}$$

System B

Depreciation = 85,000/5 = $17,000

For years 1 to 5:

$$TI = 20,000 – 17,000 = \$3,000$$
$$Taxes = 3,000(0.35) = \$1050$$
$$CFAT = 20,000 – 1050 = \$18,950$$

For year 5 only, when B is sold for 10% of first cost:

$$DR = 85,000(0.10) = \$8500$$
$$DR\ taxes = 8500(0.35) = \$2975$$

$$\begin{aligned} AW_B &= –85,000(A/P,6\%,5) + 18,950 + (8500–2975)(A/F,6\%,5) \\ &= –85,000(0.23740) + 18,950 + 5525(0.17740) \\ &= -\$249 \end{aligned}$$

Select system A

17.45 (a - 1) Classical SL with n = 5 year recovery period.

Annual depreciation = (2,500 – 0)/5 = $500

Year 1

$$Taxes = (1,500 - 500)(0.30) = \$300$$
$$\begin{aligned} CFAT &= 1,500 - 300 \\ &= \$1,200 \end{aligned}$$

Years 2-5

Taxes = (300 - 500) (0.30) = $–60

17.45 (cont) CFAT = 300 - (-60)
= $360

The rate of return relation over 5 years is

$$0 = –2,500 + 1,200(P/F,i^*,1) + 360 (P/A,i^*,4)(P/F,i^*,1)$$

$i^* = 2.36$ % (trail and error between 2% and 3%)

(b - 1) Use MACRS with n = 5 year recovery period.

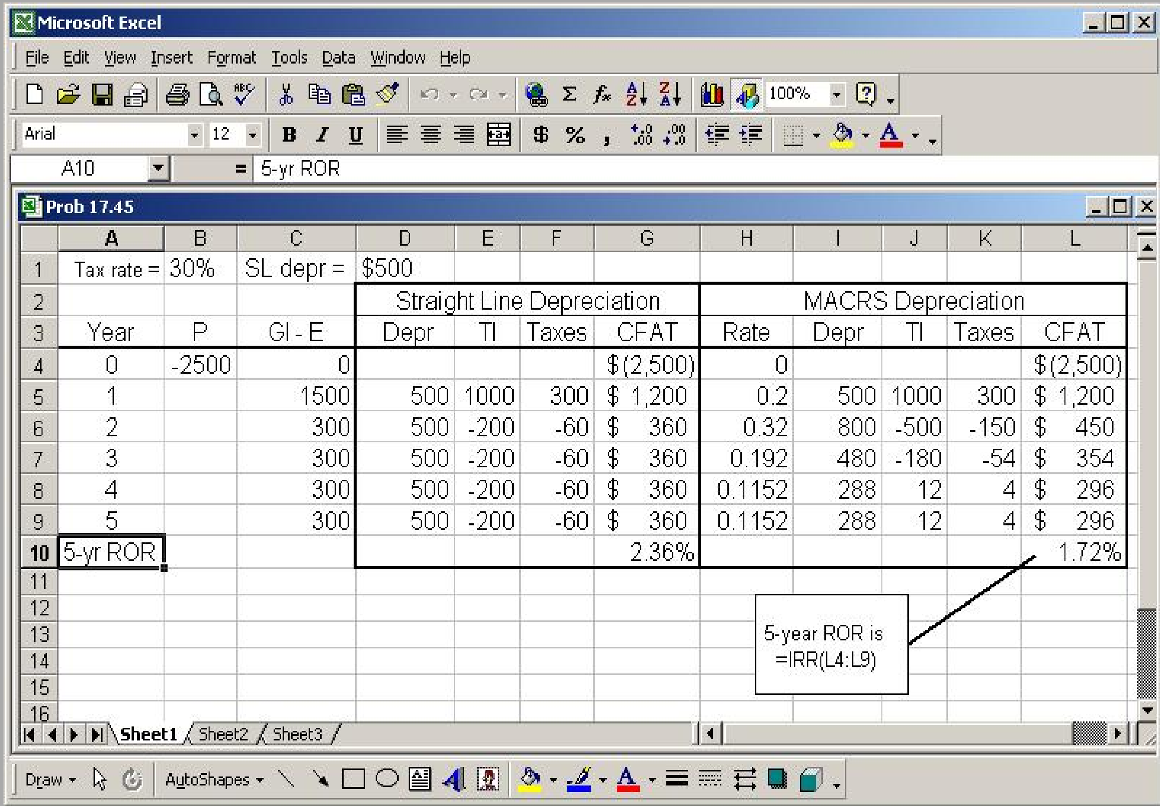
Year	P	GI - E	Depr	TI	Taxes	CFAT
0	$–2,500	-	-	-	-	-$2,500
1		$1,500	$500	$1,000	$300	1,200
2		300	800	-500	-150	450
3		300	480	-180	-54	354
4		300	288	12	4	296
5		300	288	12	4	296

The ROR relation over 6 years is

$$0 = –2500 + 1200(P/F,i^*,1) + ... + 296(P/F,i^*,5)$$
$i^* = 1.71\%$ (trial and error between 1% and 2%)

Note that 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.

(b – 1 and 2) Spreadsheet solutions



	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%

17.46 For a 12% after-tax return, find n by trial and error in a PW relation.

$$-78{,}000 + 18{,}000(P/A,12\%,n) - 1000(P/G,12\%,n) = 0$$

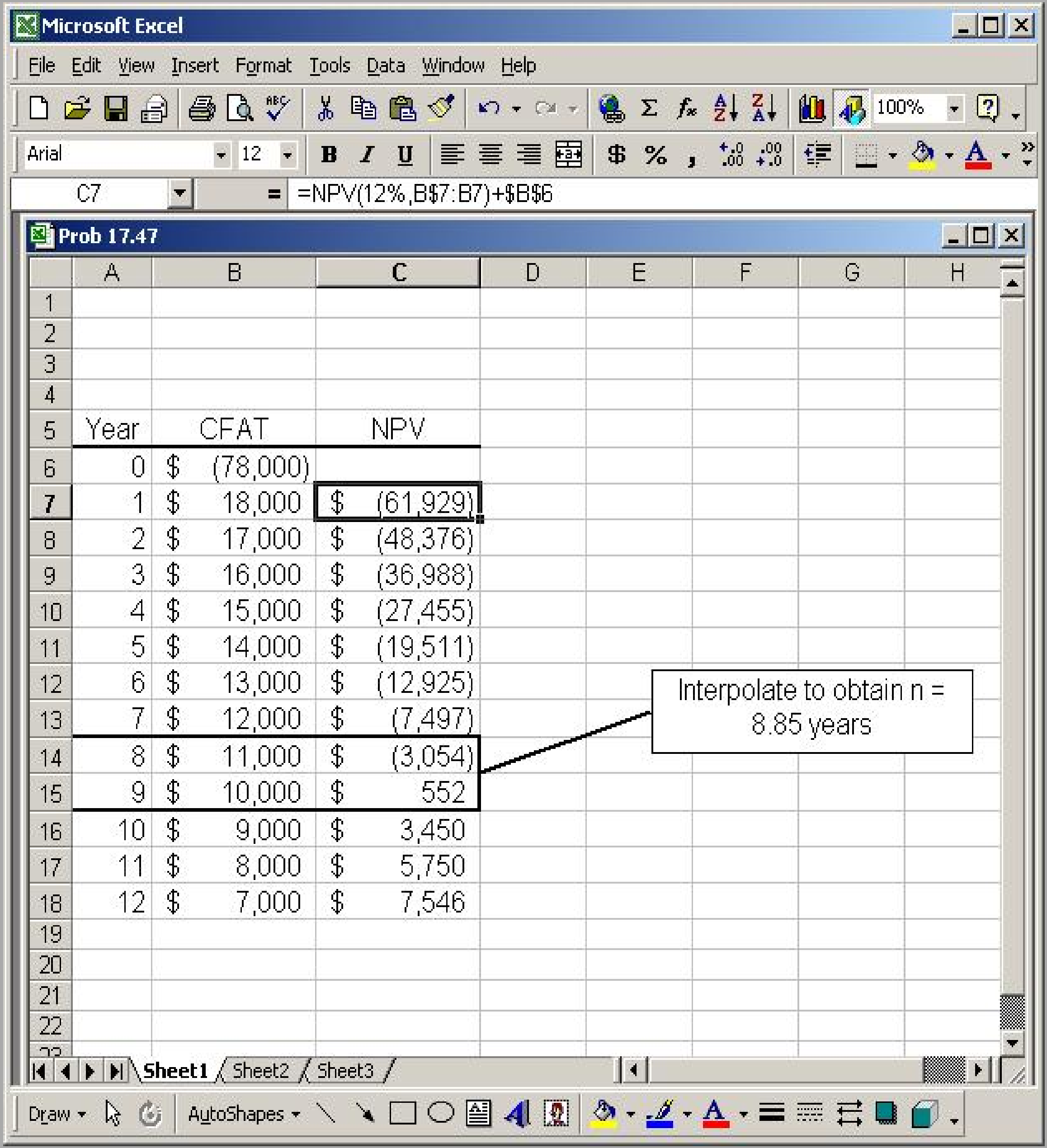
For n = 8 years: $-78{,}000 + 18{,}000(4.9676) - 1000(14.4714) = -\$3055$

For n = 9 years: $-78{,}000 + 18{,}000(5.3282) - 1000(17.3563) = \$551$

n = 8.85 years

Keep the equipment for 3.85 (or 4 rounded off) more years.

17.47 Repeatedly set up the NPV relation until the PW value becomes positive, then interpolate to estimate n.



Year	CFAT	NPV
0	$ (78,000)	
1	$ 18,000	$ (61,929)
2	$ 17,000	$ (48,376)
3	$ 16,000	$ (36,988)
4	$ 15,000	$ (27,455)
5	$ 14,000	$ (19,511)
6	$ 13,000	$ (12,925)
7	$ 12,000	$ (7,497)
8	$ 11,000	$ (3,054)
9	$ 10,000	$ 552
10	$ 9,000	$ 3,450
11	$ 8,000	$ 5,750
12	$ 7,000	$ 7,546

Keep the equipment for 8.85 – 5 = 3.85 more years.

17.48 (a) Get the CFAT values from Problem 17.42(b) for years 1 through 10.

$$CFAT_A = \$–900 \qquad\qquad CFAT_B = \$+100$$

Use a spreadsheet to find the incremental ROR (column D) and to determine the PW of incremental CFAT versus incremental i values (columns E and F) for the chart.

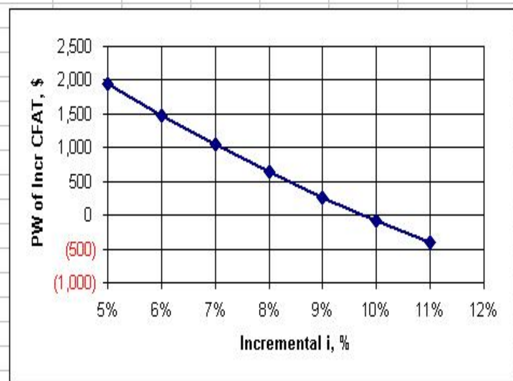
The incremental i* = 9.75% can also be found using the PW relation:

$$0 = –7000 + 1000(P/A,i^*,9) + 3000(P/F,i^*,10)$$

If MARR < 9.75%, select B, otherwise select A.

Prob 17.48

Year	CFAT for A	CFAT for B	Incremental CFAT	Incr i, %	PW of incr CFAT, $
0	(15,000)	(22,000)	(7,000)	5%	1,950
1	(900)	100	1,000	6%	1,477
2	(900)	100	1,000	7%	1,040
3	(900)	100	1,000	8%	636
4	(900)	100	1,000	9%	262
5	(900)	100	1,000	10%	(84)
6	(900)	100	1,000	11%	(406)
7	(900)	100	1,000		
8	(900)	100	1,000		
9	(900)	100	1,000		
10	2,100	5,100	3,000		
	(a) Incremental i* =		9.75%		



(b) Use the PW vs. incremental i plot to select between A and B at each MARR value.

MARR	Select
5%	B
9	B
10	A
12	A

17.49 (a) The equation to determine the required first cost P is

$$
\begin{aligned}
0 &= -P + (CFBT - taxes)(P/A,20\%,5) \\
&= -P + [20{,}000 - (20{,}000 - P/5)(0.40)](P/A,20,\%5) \\
&= -P + [12{,}000 + 0.08P](2.9906) \\
&= -P + 35{,}887 + 0.23925P
\end{aligned}
$$

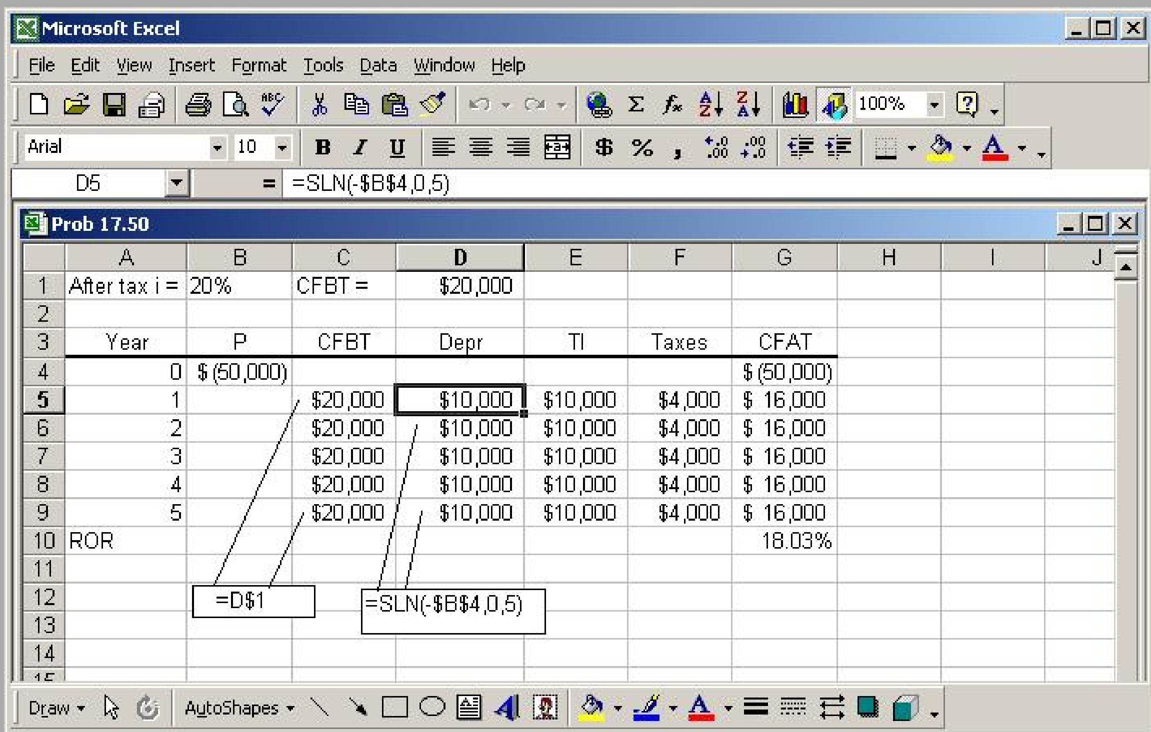
$$P = \$47{,}173$$

(b) Let CFBT = C. The equation to find the required CFBT is

$$
\begin{aligned}
0 &= -50{,}000 + \{C - [C - 10{,}000](0.40)\}(P/A,20\%,5) \\
&= -50{,}000 + \{0.6C(2.9906) \ + 4{,}000(2.9906) \\
&= -50{,}000 + 1.79436C + 11{,}962 \\
&= -\ 38{,}038 + 1.79436C
\end{aligned}
$$

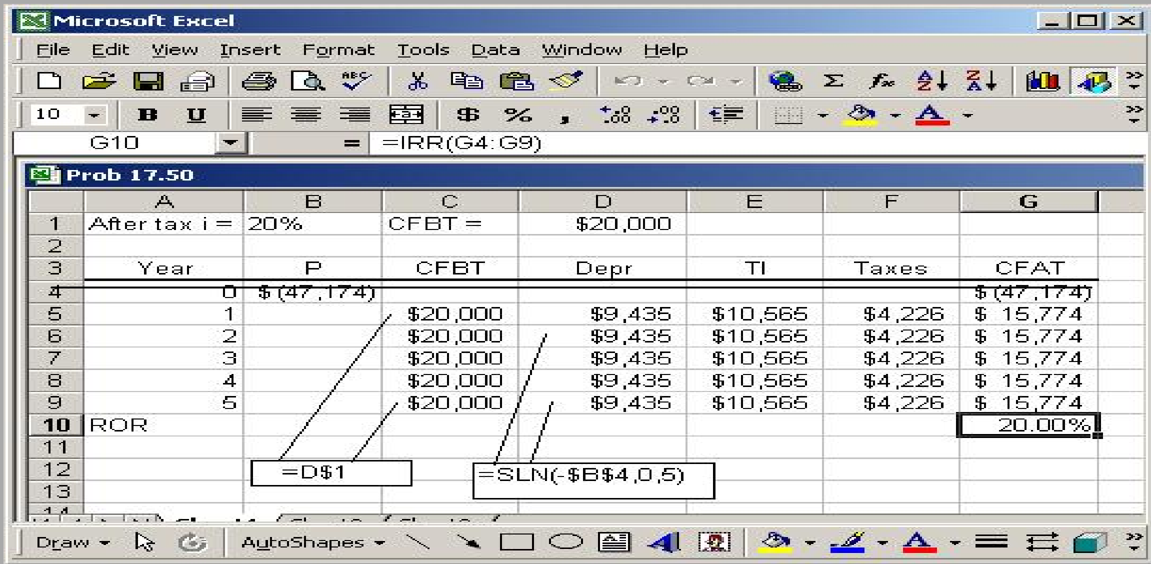
CFBT = $21,198

17.50 (a) Set up spreadsheet and find ROR = 18.03%.



	A	B	C	D	E	F	G
1	After tax i =	20%	CFBT =	$20,000			
2							
3	Year	P	CFBT	Depr	TI	Taxes	CFAT
4	0	$ (50,000)					$ (50,000)
5	1		$20,000	$10,000	$10,000	$4,000	$ 16,000
6	2		$20,000	$10,000	$10,000	$4,000	$ 16,000
7	3		$20,000	$10,000	$10,000	$4,000	$ 16,000
8	4		$20,000	$10,000	$10,000	$4,000	$ 16,000
9	5		$20,000	$10,000	$10,000	$4,000	$ 16,000
10	ROR						18.03%

17.50 (cont) For a 20% return, use SOLVER with B4 (first cost, P) as the changing cell and G10 as the target cell to obtain a new P = $47,174. Many of the other values change accordingly, as shown here on the resulting spreadsheet once SOLVER is complete.



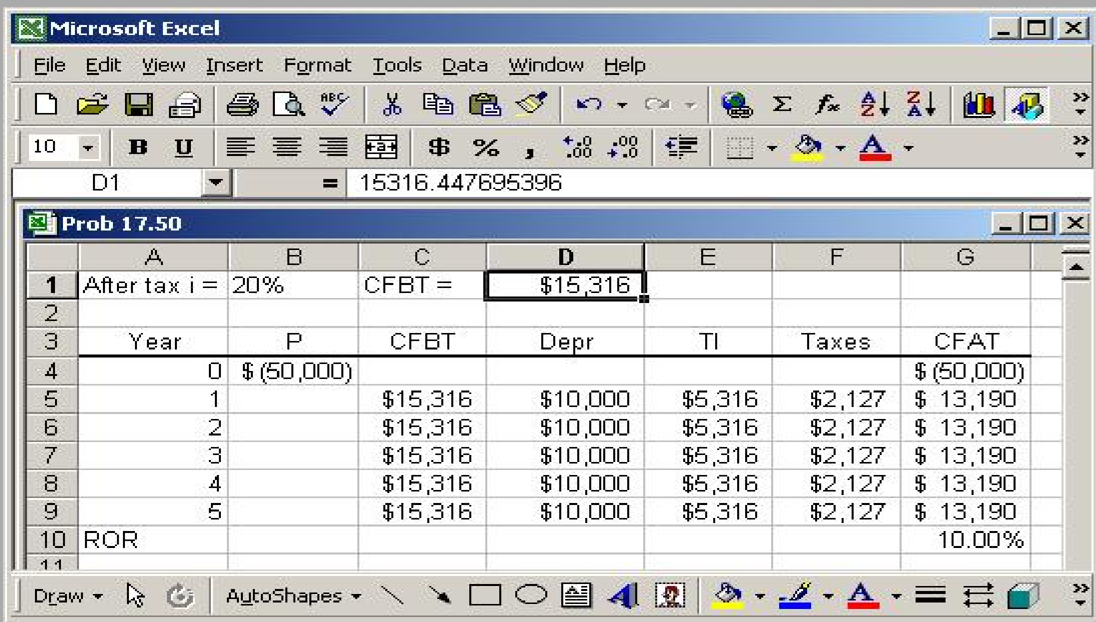
G10 =IRR(G4:G9)

Prob 17.50

	A	B	C	D	E	F	G
1	After tax i =	20%	CFBT =	$20,000			
2							
3	Year	P	CFBT	Depr	TI	Taxes	CFAT
4	0	$ (47,174)					$ (47,174)
5	1		$20,000	$9,435	$10,565	$4,226	$ 15,774
6	2		$20,000	$9,435	$10,565	$4,226	$ 15,774
7	3		$20,000	$9,435	$10,565	$4,226	$ 15,774
8	4		$20,000	$9,435	$10,565	$4,226	$ 15,774
9	5		$20,000	$9,435	$10,565	$4,226	$ 15,774
10	ROR						20.00%

To use SOLVER to find CFBT, make D1 the changing cell. The following answers are obtained for P and CFBT at 20% and 10%:

After-tax Return	First cost	CFBT
(a) 20%	$47,174(display above)	$21,198
(b) 10%	$65,289	$15,316 (display below)



D1 = 15316.447695396

Prob 17.50

	A	B	C	D	E	F	G
1	After tax i =	20%	CFBT =	$15,316			
2							
3	Year	P	CFBT	Depr	TI	Taxes	CFAT
4	0	$ (50,000)					$ (50,000)
5	1		$15,316	$10,000	$5,316	$2,127	$ 13,190
6	2		$15,316	$10,000	$5,316	$2,127	$ 13,190
7	3		$15,316	$10,000	$5,316	$2,127	$ 13,190
8	4		$15,316	$10,000	$5,316	$2,127	$ 13,190
9	5		$15,316	$10,000	$5,316	$2,127	$ 13,190
10	ROR						10.00%

Since 20% >18.03%, either a lower first cost is required or a larger CFBT is required to make the 20%. Similarly, since 10% < 18.03%, the first cost investment can be higher or less CFBT is required to make the 10%.

17.51 Defender

Original life estimate was 12 years.

Annual SL depreciation = 450,000 /12 = \$37,500

Annual tax savings = (37,500 + 160,000)(0.32) = \$63,200

AW_D = -50,000(A/P,10%,5) – 160,000 + 63,200
= -50,000(0.2638) – 96,800
= \$–109,990

Challenger

Book value of D = 450,000 – 7(37,500) = \$187,500

CL from sale of D = BV_7 – Market value
= 187,500 – 50,000 = \$137,500

Tax savings from CL, year 0 = 137,500(0.32) = \$44,000

Challenger annual SL depreciation = $\frac{700{,}000 - 50{,}000}{10}$ = \$65,000

Annual tax saving = (65,000 +150,000)(0.32) = \$68,800

Challenger DR when sold in year 8 = \$0

AW_C =(–700,000 + 44,000)(A/P,10%,10) + 50,000(A/F,10%,10) – 150,000 + 68,800
= –656,000(0.16275) + 50,000(0.06275) – 81,200
= \$-184,827

Select the defender. Decision was incorrect since D has a lower AW value of costs.

17.52 (a) Lives are set at 5 (remaining) for the defender and 8 years for the challenger.

Defender

$$\text{Annual depreciation} = \frac{28{,}000 - 2000}{10} = \$2600$$

Annual tax savings = (2600 + 1200)(0.06) = \$228

$$\begin{aligned} AW_D &= -15{,}000(A/P,6\%,5) + 2000(A/F,6\%,5) - 1200 + 228 \\ &= -15{,}000(0.2374) + 2000(0.1774) - 1200 + 228 \\ &= \$-4178 \end{aligned}$$

Challenger

$$\begin{aligned} \text{DR from sale of D} &= \text{Market value} - BV_5 \\ &= 15{,}000 - [28{,}000 - 5(2600)] = 0 \end{aligned}$$

$$\text{Challenger annual depreciation} = \frac{15{,}000 - 3000}{8} = \$1500$$

Annual tax saving = (1,500 + 1,500)(0.06) = \$180

Challenger DR, year 8 = 3000 – 3000 = 0

$$\begin{aligned} AW_C &= -15{,}000(A/P,6\%,8) + 3000(A/F,6\%,8) - 1500 + 180 \\ &= -15{,}000(0.16104) + 3000(0.10104) - 1320 \\ &= \$-3432 \end{aligned}$$

Select the challenger

(b)
$$\begin{aligned} AW_D &= -15{,}000(A/P,12\%,5) + 2000(A/F,12\%,5) - 1200 \\ &= -15{,}000(0.27741) + 2000(0.15741) - 1200 \\ &= \$-5046 \end{aligned}$$

$$\begin{aligned} AW_C &= -15{,}000(A/P,12\%,8) + 3000(A/F,12\%,8) - 1500 \\ &= -15{,}000(0.2013) + 3000(0.0813) - 1500 \\ &= \$-4276 \end{aligned}$$

Select the challenger. The before-tax and after-tax decisions are the same.

17.53 Challenger (in $1,000 units)

Challenger annual depreciation = (15,000 – 300)/8 = $1500

Challenger DR from sale = Market value – BV_5
= 10,000 – [15,000 – 5(1500)] = $2500

Taxes from DR, year 5 = 2500(0.06) = $150

Annual tax saving = (1,500 + 1,500)(0.06) = $180

Now, calculate AW_C over the 5 years that C was actually in service.

AW_C = –15,000(A/P,6%,5) + 10,000(A/F,6%,5) – 1500 + 180 – 150(A/F,6%,5)
= –15,000(0.2374) + 10,000(0.1774) – 1320 – 150(0.1774)

= $–3134

From Problem 17.52(a), AW_D = $–4178
Challenger was the correct decision 5 years ago.

17.54 Study period is fixed at 3 years. Follow the analysis logic in Section 11.5.

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

17.54 (cont)

Challenger

No tax effect if (defender) contract is cancelled. Calculate CFAT for 1, 2, and 3 years of ownership. Tax rate is 35%.

Yr	Exp	d	Depr	BV	SP	DR or CL	TI	Tax savings	CFAT
0	-	-	-	\$800,000	-	-	-	-	\$–800,000
1	\$120,000	0.3333	\$266,640	533,360	\$600,000	\$ 66,640 DR	\$–320,000	\$–112,000	592,000
2	120,000	0.4445	355,600	177,760	400,000	222,240 DR	–253,360	– 88,676	368,676
3	120,000	0.1481	118,480	59,280	200,000	140,720 DR	– 97,760	– 34,216	114,216

TI = –Exp – Depr + DR – CL

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 = –E + 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

Option	Year 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.

17.55 (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 saving, 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

Challenger

DR on defender = $15,000
DR tax = $6000
First cost + DR tax = $46,000
Depreciation = 40,000/5 = $8,000
Expenses = $7,000 (years 1-5)
Tax saving = (8000 + 7000)(0.4) = $6,000
Actual AOC = 7000 – 6000 = $1000 (years 1-5)

17.55 (cont)

$$AW_C = -46{,}000(A/P,12\%,5) - 1000$$
$$= -46{,}000(0.27741) - 1000$$
$$= \$-13{,}761$$

Retain the defender since the AW of cost is smaller.

(b) AW_C will become less costly, but the revenue from the challenger's sale between \$2000 to \$4000 will be reduced by the 40% tax on DR in year.

17.56

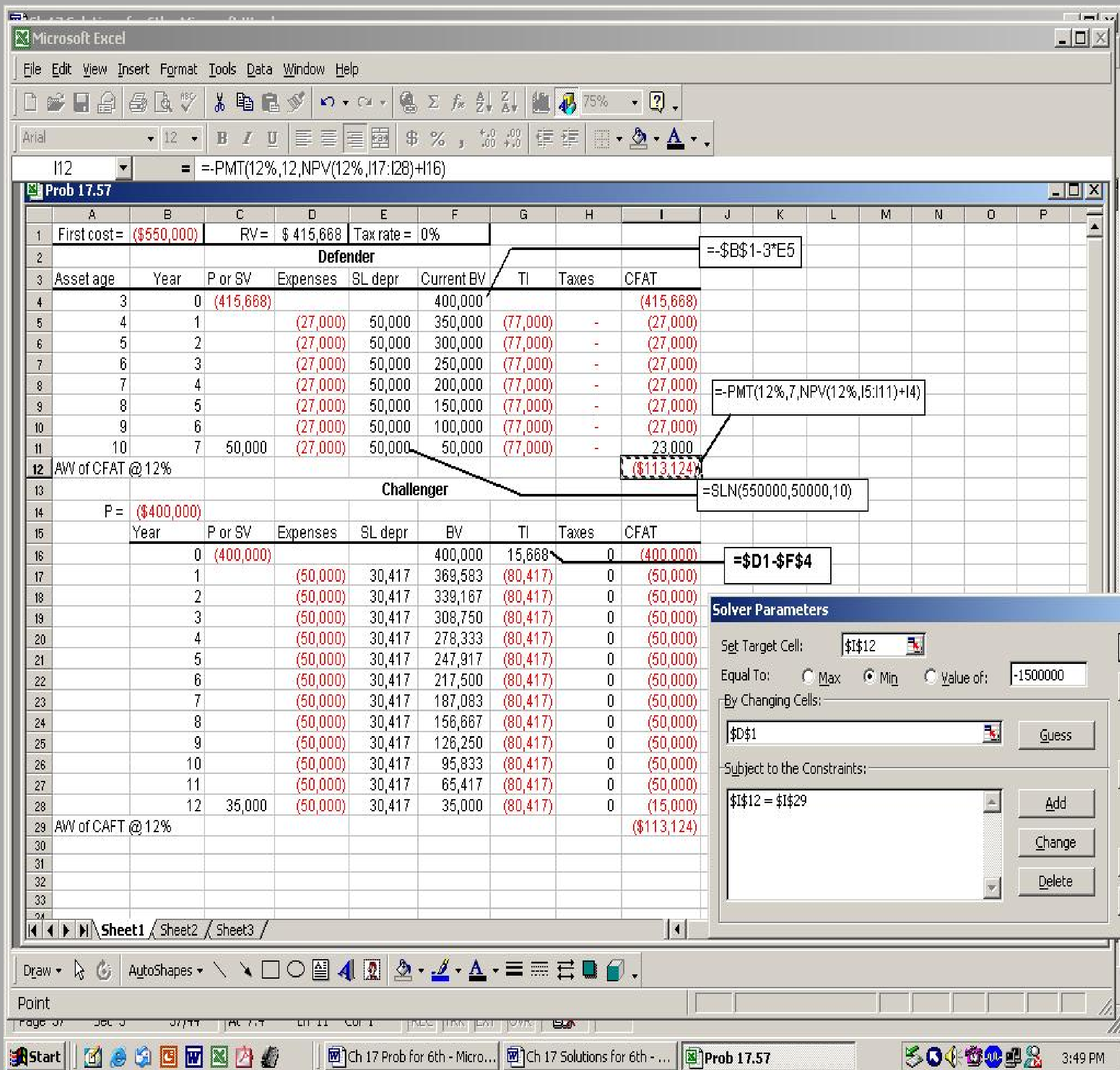
Microsoft Excel — Prob 17.56

I12 = =-PMT($B$1,5,NPV($B$1,I6:I10)+I5)

	A	B	C	D	E	F	G	H	I
1	MARR	7%							
2	Purchase	$ 600,000		Defender after-tax MACRS analysis					
3	Asset		First cost &	(Expenses)	MACRS			Tax savings	
4	age	Year	salvage value(1)	CFBT	rates	Depr	TI	34% of TI	CFAT
5	3	0	($275,000)						($275,000)
6	4	1		($100,000)	0.1249	$74,940	($174,940)	($59,480)	($40,520)
7	5	2		($100,000)	0.0893	$53,580	($153,580)	($52,217)	($47,783)
8	6	3		($100,000)	0.0892	$53,520	($153,520)	($52,197)	($47,803)
9	7	4		($100,000)	0.0893	$53,580	($153,580)	($52,217)	($47,783)
10	8	5	$0	($100,000)	0.0446	$26,760	($126,760)	($43,098)	($56,902)
11						$262,380			
12	(1)Defender assumed to be sold in year 5 (year 8 of its life) for exactly BV = 0.							AW at 7%	($114,787)
13	All of original P=$600,000 depreciated over the 8 years. No tax effect.								
14									
15	Purchase	$ 1,000,000		Challenger after-tax MACRS analysis					
16	Asset		First cost &	(Expenses)	MACRS			Tax savings	
17	age	Year	salvage value(1)	CFBT	rates	Depr	TI (2)	34% of TI	CFAT
18	0	0	($1,000,000)				$12,620	$4,291	($1,004,291)
19	1	1		($15,000)	0.2000	$200,000	($215,000)	($73,100)	$58,100
20	2	2		($15,000)	0.3200	$320,000	($335,000)	($113,900)	$98,900
21	3	3		($15,000)	0.1920	$192,000	($207,000)	($70,380)	$55,380
22	4	4		($15,000)	0.1152	$115,200	($130,200)	($44,268)	$29,268
23	5	5	$100,000	($15,000)	0.1152	$115,200	($87,800)	($29,852)	$114,852
24						$942,400			
25	(1)Challenger sold in year 5 for $100,000. The DR is:							AW at 7%	($174,183)
26	DR = SP-BV = 100,000-(1,000,000-942,400) = $42,400.								
27	DR has a tax effect on TI in year 5.								
28	(2) TI of $12,620 in year 0 is DR from trade of defender. DR = P - current BV = 275,000 - 262,380.								

Still select the defender but with a larger AW advantage.

17.57 (a) Before taxes: Spreadsheet is similar to Figure 17-8 with RV 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 = I 29 and establishing a minimum (or maximum) value so a solution can be found by SOLVER.



I12 = =-PMT(12%,12,NPV(12%,I17:I28)+I16)

Prob 17.57

	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)

17.57 (b) After taxes: If the tax rate of 30% is set (cell F1 in the spreadsheet below), RV = $414,109 is obtained in D1. So, after-tax consideration has, in the end, made a very small impact on the required RV value; only a $1559 reduction.

Microsoft Excel — Prob 17.57

G16 = =$D1-$F$4

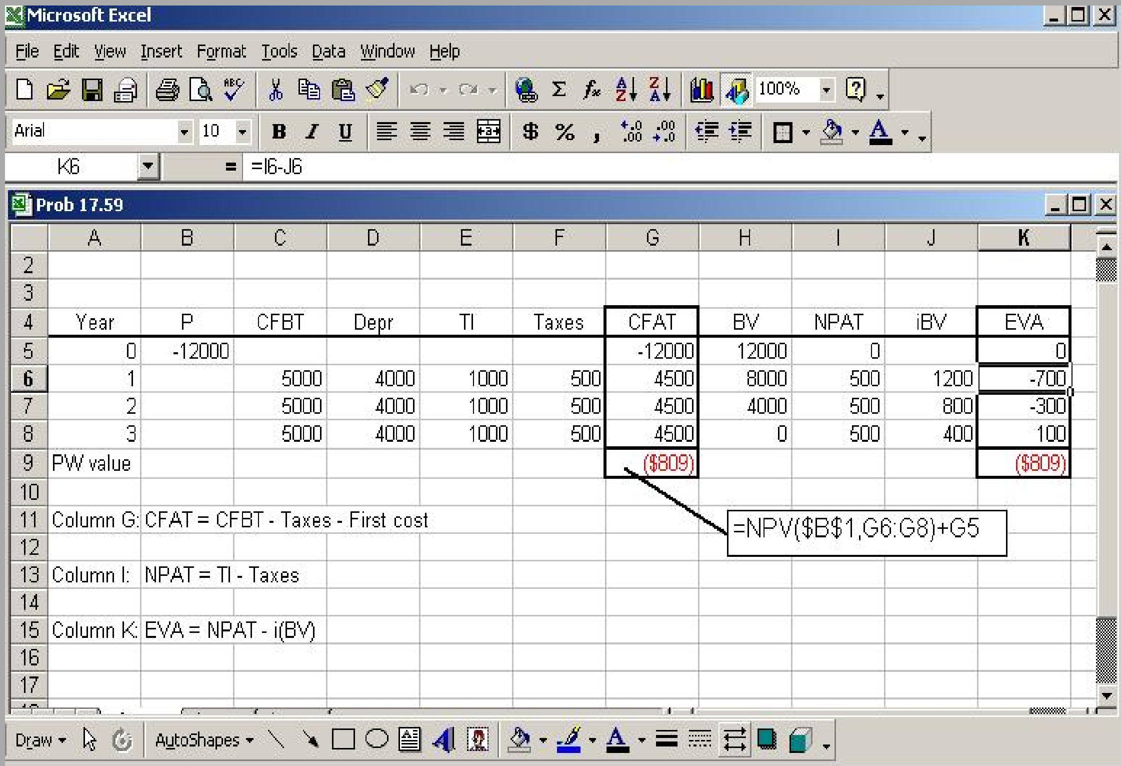
	A	B	C	D	E	F	G	H	I
1	First cost =	($550,000)	RV =	$ 414,109	Tax rate =	30%			
2				Defender					
3	Asset age	Year	P or SV	Expenses	SL depr	Current BV	TI	Taxes	CFAT
4	3	0	(414,109)			400,000			(414,109)
5	4	1		(27,000)	50,000	350,000	(77,000)	(23,100)	(3,900)
6	5	2		(27,000)	50,000	300,000	(77,000)	(23,100)	(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)

Sheet1 / Sheet2 / Sheet3

17.58 (a) The EVA shows the monetary worth added to a corporation by an alternative.

(b) The EVA estimates can be used directly in public reports (e.g., to stockholders). EVA shows worth contribution, not just CFAT.

17.59 (a) This solution uses a spreadsheet. Both PW values are the same (cells G9 and K9).



	A	B	C	D	E	F	G	H	I	J	K
2											
3											
4	Year	P	CFBT	Depr	TI	Taxes	CFAT	BV	NPAT	iBV	EVA
5	0	-12000					-12000	12000	0		0
6	1		5000	4000	1000	500	4500	8000	500	1200	-700
7	2		5000	4000	1000	500	4500	4000	500	800	-300
8	3		5000	4000	1000	500	4500	0	500	400	100
9	PW value						($809)				($809)
10											
11	Column G:	CFAT = CFBT - Taxes - First cost									
12											
13	Column I:	NPAT = TI - Taxes									
14											
15	Column K:	EVA = NPAT - i(BV)									
16											
17											

(b) Calculate the equivalent AW of P = -12,000 over 3 years that is charged against the annual CFAT = $4500, then find the PW value of the difference.

-12,000(A/P,10%,3) = -12,000(0.40211) = $-4825

CFAT – 325 = 4500 – 4825 = $-325

PW = -325(P/A,10%,3) = -325(2.4869) = $-809 = PW of EVA

17.60 (a) Take TI, taxes and D from Example 17.3. Use i = 0.10 and $T_e = 0.35$.

Microsoft Excel — Prob 17.60

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	10%	= Interest	# years =	6									
2	35%	= Tax rate											
3		Gross		Investment				Taxable			Interest on		
4		income	Expenses	& salvage	Depr.	Depr.	Book value	income			invested		
5	Year	GI	E	P and S	rate	D	BV	TI	Taxes	NPAT	capital	EVA	CFAT
6	0			(550,000)			550,000						(550,000)
7	1	200,000	(90,000)			110,000	440,000	0	0	0	55,000	(55,000)	110,000
8	2	200,000	(90,000)			176,000	264,000	(66,000)	(23,100)	(42,900)	44,000	(86,900)	133,100
9	3	200,000	(90,000)			105,600	158,400	4,400	1,540	2,860	26,400	(23,540)	108,460
10	4	200,000	(90,000)			63,360	95,040	46,640	16,324	30,316	15,840	14,476	93,676
11	5	200,000	(90,000)			63,360	31,680	46,640	16,324	30,316	9,504	20,812	93,676
12	6	200,000	(90,000)	0		31,680	0	78,320	27,412	50,908	3,168	47,740	82,588
13	7						0	0	0	0	0	0	0
14	8						0	0	0	0	0	0	0
15	9						0	0	0	0	0	0	0
16	10						0	0	0	0	0	0	0
17													
18											PW at i	($89,746)	($89,746)
19											AW at i	($20,606)	($20,606)
20													

NPAT = TI(1 – 0.35)

EVA = NPAT – interest of invested capital

(b) The spreadsheet shows that the two AW values are equal. Solution by hand is as follows:

$$\begin{aligned}
AW_{EVA} &= [-55{,}000(P/F,10\%,1) + \ldots + 47{,}740(P/F,10\%,6)](A/P,10\%,6) \\
&= [-55{,}000(0.9091) + \ldots + 47{,}740(0.5645)](0.22961) \\
&= -89{,}746(0.22961) \\
&= \$-20{,}606
\end{aligned}$$

$$\begin{aligned}
AW_{CFAT} &= [-550{,}000 + 110{,}000(P/F,10\%,1) + \ldots + 82{,}588(P/F,10\%,6)](A/P,10\%,6) \\
&= [-550{,}000 + 110{,}000(0.9091) + \ldots + 82{,}588(0.5645)](0.22961) \\
&= -89{,}746(0.22961) \\
&= \$-20{,}606
\end{aligned}$$

17.61 (a) Column L shows the EVA each year. Use Eq. [17.18} to calculate EVA.

(b) The AW_{EVA} = $338,000 is calculated on the spreadsheet.

Note: The CFAT and AW_{CFAT} values are also shown on the spreadsheet.

Microsoft Excel — Prob 17.61

M15 = =-PMT($A$1,$D$1,$M14)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	12%	= Interest	# years =	6			(in $1000)						
2	35%	= Tax rate											
3		Gross		Investment				Taxable			Interest on		
4		income	Expenses	& salvage	Depr.	Depr.	Book value	income			invested		
5	Year	GI	E	P and S	rate	D	BV	TI	Taxes	NPAT	Capital	EVA	CFAT
6	0			(3,000)			3,000						(3,000)
7	1	2,700	(1,000)		0.10	300	2,700	1,400	490	910	360	550	1,210
8	2	2,600	(1,050)		0.20	600	2,100	950	333	618	324	294	1,218
9	3	2,500	(1,100)		0.20	600	1,500	800	280	520	252	268	1,120
10	4	2,400	(1,150)		0.20	600	900	650	228	423	180	243	1,023
11	5	2,300	(1,200)		0.20	600	300	500	175	325	108	217	925
12	6	2,200	(1,250)		0.10	300	0	650	228	423	36	387	723
13						3,000							
14											PW at i	$1,389	$1,389
15											AW at i	$338	$338

=$H12-$I12

=$G11*$A$1

=$J12-$K12

17.62 The spreadsheet shows EVA for both analyzers. Select analyzer 2 with the larger AW of EVA. This is the same decision reached using AW of CFAT in Example 17.11 when the time value of money was considered. (Note: Be sure to read both Examples 17.6 and 17.11 before working this problem.)

L29 =-PMT($A$1,$D$1,$L28)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	10%	= Interest	# years =	6									
2	35%	= Tax rate				**EVA analysis of Analyzer 1**							
3		Gross		Investment				Taxable			Interest on		
4		income	Expenses	& salvage	Depr.	Depr.	Book value	income			invested		
5	Year	GI	E	P and S	rate	D	BV	TI	Taxes	NPAT	capital	EVA	CFAT
6	0			(150,000)			150,000						(150,000)
7	1	100,000	(30,000)		0.2000	30,000	120,000	40,000	14,000	26,000	15,000	11,000	56,000
8	2	100,000	(30,000)		0.3200	48,000	72,000	22,000	7,700	14,300	12,000	2,300	62,300
9	3	100,000	(30,000)		0.1920	28,800	43,200	41,200	14,420	26,780	7,200	19,580	55,580
10	4	100,000	(30,000)		0.1152	17,280	25,920	52,720	18,452	34,268	4,320	29,948	51,548
11	5	100,000	(30,000)		0.1152	17,280	8,640	52,720	18,452	34,268	2,592	31,676	51,548
12	6	100,000	(30,000)	0	0.0576	8,640	0	61,360	21,476	39,884	864	39,020	48,524
13						150,000							
14											PW at i	$88,761	$88,761
15											AW at i	**$20,380**	$20,380
16						**EVA analysis of Analyzer 2**							
17		Gross		Investment				Taxable			Interest on		
18		income	Expenses	& salvage	Depr.	Depr.	Book value	income			invested		
19	Year	GI	E	P and S	rate	D	BV	TI	Taxes	NPAT	capital	EVA	CFAT
20	0			(225,000)			225,000						(225,000)
21	1	100,000	(10,000)		0.2000	45,000	180,000	45,000	15,750	29,250	22,500	6,750	74,250
22	2	100,000	(10,000)		0.3200	72,000	108,000	18,000	6,300	11,700	18,000	(6,300)	83,700
23	3	100,000	(10,000)		0.1920	43,200	64,800	46,800	16,380	30,420	10,800	19,620	73,620
24	4	100,000	(10,000)		0.1152	25,920	38,880	64,080	22,428	41,652	6,480	35,172	67,572
25	5	100,000	(10,000)		0.1152	25,920	12,960	64,080	22,428	41,652	3,888	37,764	67,572
26	6	100,000	(10,000)	0	0.0576	12,960	0	77,040	26,964	50,076	1,296	48,780	63,036
27						225,000							
28											PW at i	$90,677	$90,677
29				Decision: Select analyzer 2							AW at i	**$20,820**	$20,820
30													

Case Study Solution

1. Set up on the next two spreadsheets. 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 D-E mixes are risky.

Microsoft Excel - C17 - Case Study soln

0% debt and 100% equity financing — Capital = $ 1,500,000

		Debt financing (loan)		Equity	MACRS			Taxes	
Year	GI - E	Interest[1]	Principal	investment	rate	Depr.	TI	@ 35%	CFAT
0				($1,500,000)	-				($1,500,000)
1	$600,000	$0	$0		0.2000	$300,000	$300,000	$105,000	$495,000
2	$600,000	$0	$0		0.3200	$480,000	$120,000	$42,000	$558,000
3	$600,000	$0	$0		0.1920	$288,000	$312,000	$109,200	$490,800
4	$600,000	$0	$0		0.1152	$172,800	$427,200	$149,520	$450,480
5	$600,000	$0	$0		0.1152	$172,800	$427,200	$149,520	$450,480
6	$600,000			$0	0.0576	$86,400	$513,600	$179,760	$420,240
Totals					1.0000	$1,500,000		$735,000	$1,365,000
PW at 10%									$604,513

(1) Interest plus principal = $ debt/5 + ($ debt)(0.06)

50% debt and 50% equity financing

		Debt financing (loan)		Equity	MACRS			Taxes	
Year	GI - E	Interest[1]	Principal	investment	rate	Depr.	TI	@ 35%	CFAT
0				($750,000)	-				($750,000)
1	$600,000	($45,000)	($150,000)		0.2000	$300,000	$255,000	$89,250	$315,750
2	$600,000	($45,000)	($150,000)		0.3200	$480,000	$75,000	$26,250	$378,750
3	$600,000	($45,000)	($150,000)		0.1920	$288,000	$267,000	$93,450	$311,550
4	$600,000	($45,000)	($150,000)		0.1152	$172,800	$382,200	$133,770	$271,230
5	$600,000	($45,000)	($150,000)		0.1152	$172,800	$382,200	$133,770	$271,230
6	$600,000			$0	0.0576	$86,400	$513,600	$179,760	$420,240
Totals					1.0000	$1,500,000		$656,250	$1,218,750
PW at 10%									$675,015

There are three worksheets for this case study solution

Microsoft Excel - C17 - Case Study soln

70% debt and 30% equity financing — Capital = $ 1,500,000

Year	GI - E	Debt financing (loan) Interest	Debt financing (loan) Principal	Equity investment	MACRS rate	Depr.	TI	Taxes @ 35%	CFAT
0				($450,000)	-				($450,000)
1	$600,000	($63,000)	($210,000)		0.2000	$300,000	$237,000	$82,950	$244,050
2	$600,000	($63,000)	($210,000)		0.3200	$480,000	$57,000	$19,950	$307,050
3	$600,000	($63,000)	($210,000)		0.1920	$288,000	$249,000	$87,150	$239,850
4	$600,000	($63,000)	($210,000)		0.1152	$172,800	$364,200	$127,470	$199,530
5	$600,000	($63,000)	($210,000)		0.1152	$172,800	$364,200	$127,470	$199,530
6	$600,000			$0	0.0576	$86,400	$513,600	$179,760	$420,240
Totals					1.0000	$1,500,000		$624,750	$1,160,250
PW at 10%									$703,215

90% debt and 10% equity financing

Year	GI - E	Debt financing (loan) Interest	Debt financing (loan) Principal	Equity investment	MACRS rate	Depr.	TI	Taxes @ 35%	CFAT
0				($150,000)	-				($150,000)
1	$600,000	($81,000)	($270,000)		0.2000	$300,000	$219,000	$76,650	$172,350
2	$600,000	($81,000)	($270,000)		0.3200	$480,000	$39,000	$13,650	$235,350
3	$600,000	($81,000)	($270,000)		0.1920	$288,000	$231,000	$80,850	$168,150
4	$600,000	($81,000)	($270,000)		0.1152	$172,800	$346,200	$121,170	$127,830
5	$600,000	($81,000)	($270,000)		0.1152	$172,800	$346,200	$121,170	$127,830
6	$600,000			$0	0.0576	$86,400	$513,600	$179,760	$420,240
Totals					1.0000	$1,500,000		$593,250	$1,101,750
PW at 10%									$731,416

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.

58,500/2 = $29,250

Conclusion: Total CFAT increases by $29,250 for each 10% increase in equity financing.

3. This happens because less of the Young Brothers own funds are committed to the Portland branch the larger the loan principal.

4. The best estimates of annual EVA are shown in column M.
The equivalent AW = $113,342.

Exercise #4) EVA for 50%-50% financing

50% debt and 50% equity financing — Capital = $ 1,500,000

Year	GI - E	Debt financing (loan) Interest[1]	Principal	Equity investment	MACRS rate	Depr.	Book value BV	TI	Taxes @ 35%	NPAT	Interest on invested capital[1]	EVA
0				($750,000)	-		$ 1,500,000					
1	$600,000	($45,000)	($150,000)		0.2000	$300,000	$ 1,200,000	$255,000	$89,250	$165,750	$150,000	$15,750
2	$600,000	($45,000)	($150,000)		0.3200	$480,000	$ 720,000	$75,000	$26,250	$48,750	$120,000	($71,250)
3	$600,000	($45,000)	($150,000)		0.1920	$288,000	$ 432,000	$267,000	$93,450	$173,550	$72,000	$101,550
4	$600,000	($45,000)	($150,000)		0.1152	$172,800	$ 259,200	$382,200	$133,770	$248,430	$43,200	$205,230
5	$600,000	($45,000)	($150,000)		0.1152	$172,800	$ 86,400	$382,200	$133,770	$248,430	$25,920	$222,510
6	$600,000			$0	0.0576	$86,400	$ -	$513,600	$179,760	$333,840	$8,640	$325,200
Totals					1.0000	$1,500,000			$656,250			
PW at 10%												$493,633
AW @ 10%												$113,342

(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:

EVA = NPAT – interest on invested capital

NPAT = TI – taxes

$$(\text{Interest on invested capital})_t = i(\text{BV in the previous year}) = 0.10(BV_{t-1})$$

Note: BV on the entire $1.5 million in depreciable assets is used to determine the interest on invested capital.

Chapter 18
Formalized Sensitivity Analysis and Expected Value Decisions

Solutions to Problems

18.1 <u>10 tons/day</u>

$$\begin{aligned} PW &= -62{,}000 + 1500P/F,10\%,8) - 0.50(10)(200)(P/A,10\%,8) - 4(8)(200)(P/A,10\%,8) \\ &= -62{,}000 + 1500(0.4665) - 7400(5.3349) \\ &= \$-100{,}779 \end{aligned}$$

<u>20 tons/day</u>

$$\begin{aligned} PW &= -62{,}000 + 1500(P/F,10\%,8) - 0.50(20)(200)(P/A,10\%,8) \\ &\quad - 8(8)(200)(P/A,10\%,8) \\ &= -62{,}000 + 1500(0.4665) - 14{,}800(5.3349) \\ &= \$-140{,}257 \end{aligned}$$

<u>30 tons/day</u>

Overtime hours required = (30/20)8 – 8 = 4.0 hours

$$\begin{aligned} PW &= -62{,}000 + 1500(P/F,10\%,8) - 0.50(30)(200)(P/A,10\%,8) \\ &\quad - [8(8)(200) + 4.0(16)(200)](P/A,10\%,8) \\ &= -62{,}000 + 1500(0.4665) - 28{,}600(5.3349) \\ &= \$-213{,}878 \end{aligned}$$

18.2 Joe:

$$\begin{aligned} PW &= -77{,}000 + 10{,}000(P/F,8\%,6) + 10{,}000(P/A,8\%,6) \\ &= -77{,}000 + 10{,}000(0.6302) + 10{,}000(4.6229) \\ &= \$-24{,}469 \end{aligned}$$

Jane:

$$\begin{aligned} PW &= -77{,}000 + 10{,}000(P/F,8\%,6) + 14{,}000(P/A,8\%,6) \\ &= -77{,}000 + 10{,}000(0.6302) + 14{,}000(4.6229) \\ &= \$-5977 \end{aligned}$$

Carlos:

$$\begin{aligned} PW &= -77{,}000 + 10{,}000(P/F,8\%,6) + 18{,}000(P/A,8\%,6) \\ &= -77{,}000 + 10{,}000(0.6302) + 18{,}000(4.6229) \\ &= \$12{,}514 \end{aligned}$$

Only the $18,000 revenue estimate of Carlos favors the investment.

18.3 Set up the spreadsheets for income estimates of $10,000, 14,000 and 18,000 and calculate the PW at 8(1-0.35) = 5.2%. The $18,000 revenue estimate is the only one with PW > 0.

Joe: $10,000 = Revenue estimate

Year	Revenue	Expenses	P and S	MACRS Depreciation	Taxable income	Taxes	CFAT
0			-77000				$ (77,000)
1	10000	2000		$ 15,400	$ (7,400)	$ (2,590)	$ 10,590
2	10000	2000		$ 24,640	$ (16,640)	$ (5,824)	$ 13,824
3	10000	2000		$ 14,784	$ (6,784)	$ (2,374)	$ 10,374
4	10000	2000		$ 8,870	$ (870)	$ (305)	$ 8,305
5	10000	2000		$ 8,870	$ (870)	$ (305)	$ 8,305
6	10000	2000	10000	$ 4,435	$ (6,435)	$ (2,252)	$ 20,252

TI = B - C - D

CFAT = B - C + D - G

Depr. Recapture in year 6 is $10,000

PW of CFAT = $ (17,365)

Jane: $14,000 = Revenue estimate

Year	Revenue	Expenses	P and S	MACRS Depreciation	Taxable income	Taxes	CFAT
0			-77000				$ (77,000)
1	14000	2000		$ 15,400	$ (3,400)	$ (1,190)	$ 13,190
2	14000	2000		$ 24,640	$ (12,640)	$ (4,424)	$ 16,424
3	14000	2000		$ 14,784	$ (2,784)	$ (974)	$ 12,974
4	14000	2000		$ 8,870	$ 3,130	$ 1,095	$ 10,905
5	14000	2000		$ 8,870	$ 3,130	$ 1,095	$ 10,905
6	14000	2000	10000	$ 4,435	$ (2,435)	$ (852)	$ 22,852

PW of CFAT = $ (4,252)

Carlos: $18,000 = Revenue estimate

Year	Revenue	Expenses	P and S	MACRS Depreciation	Taxable income	Taxes	CFAT
0			-77000				$ (77,000)
1	18000	2000		$ 15,400	$ 600	$ 210	$ 15,790
2	18000	2000		$ 24,640	$ (8,640)	$ (3,024)	$ 19,024
3	18000	2000		$ 14,784	$ 1,216	$ 426	$ 15,574
4	18000	2000		$ 8,870	$ 7,130	$ 2,495	$ 13,505
5	18000	2000		$ 8,870	$ 7,130	$ 2,495	$ 13,505
6	18000	2000	10000	$ 4,435	$ 1,565	$ 548	$ 25,452

PW of CFAT = $ 8,861

18.4

$$PW_{Build} = –80,000 – 70(1000) + 120,000(P/F,20\%,3)$$
$$= –150,000 + 120,000(0.5787)$$
$$= \$-80,556$$

$$PW_{Lease} = –(2.5)(12)(1000) – (2.50)(12)(1000)(P/A,20\%,2)$$
$$= –18,000 – 18,000(1.5278)$$
$$= \$–75,834$$

The company should lease the space. New construction cost = 70(0.90) = $63 and lease at $2.75

$$PW_{Build} = –80,000 – 63(1000) + 120,000(P/F,20\%,3)$$
$$= –143,000 + 120,000(0.5787)$$
$$= \$–73,556$$

$$PW_{Lease} = –2.75(12)(1000)[1 + (P/A,20\%,2)]$$
$$= –15,000(2.5278)$$
$$= \$–83,417$$

Select build, the decision is sensitive.

18.5 Calculate i* for G = $1500, 2000 and 2500. Other gradient values can be used. All $ values are in $1000.

(a and b) Solution by Hand and Computer provide the same answers.

Microsoft Excel - Prob 18.5

	A	B	C	D	E	F	G	H	I
1									
2		First		Gradient =	$ (1,500)	Gradient =	$ (2,000)	Gradient =	$ (2,500)
3	Year	cost	Expenses	Revenue	CFBT	Revenue	CFBT	Revenue	CFBT
4	0	$ (74,000)			$ (74,000)		$ (74,000)		$ (74,000)
5	1		$ (30,000)	$ 63,000	$ 33,000	$ 63,000	$ 33,000	$ 63,000	$ 33,000
6	2		$ (33,000)	$ 61,500	$ 28,500	$ 61,000	$ 28,000	$ 60,500	$ 27,500
7	3		$ (36,000)	$ 60,000	$ 24,000	$ 59,000	$ 23,000	$ 58,000	$ 22,000
8	4		$ (39,000)	$ 58,500	$ 19,500	$ 57,000	$ 18,000	$ 55,500	$ 16,500
9	5		$ (42,000)	$ 57,000	$ 15,000	$ 55,000	$ 13,000	$ 53,000	$ 11,000
10	6		$ (45,000)	$ 55,500	$ 10,500	$ 53,000	$ 8,000	$ 50,500	$ 5,500
11	7		$ (48,000)	$ 54,000	$ 6,000	$ 51,000	$ 3,000	$ 48,000	$ -
12	8		$ (51,000)	$ 52,500	$ 1,500	$ 49,000	$ (2,000)	$ 45,500	$ (5,500)
13	9		$ (54,000)	$ 51,000	$ (3,000)	$ 47,000	$ (7,000)	$ 43,000	$ (11,000)
14	10		$ (57,000)	$ 49,500	$ (7,500)	$ 45,000	$ (12,000)	$ 40,500	$ (16,500)
15	Overall ROR				24.20%		19.93%		13.14%

For MARR = 18%, the decision does change from YES for G = $1500 and $2000, to NO for G = $2500.

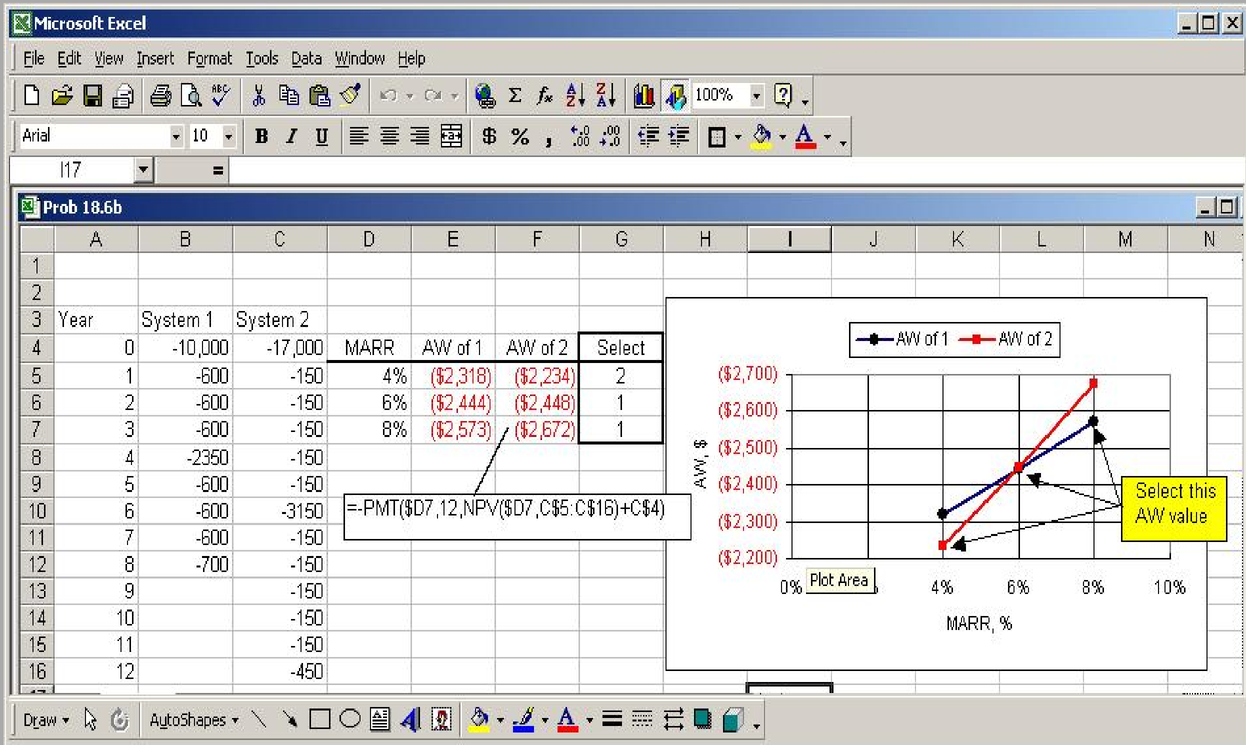
18.6 (a) The AW relations are: $AW_1 = –10,000(A/P,i,8) – 600 –100(A/F,i,8) – 1750(P/F,i,4)(A/P,i,8)$

$AW_2 = –17,000(A/P,i,12) – 150 – 300(A/F,i,12) – 3000(P/F,i,6)(A/P,i,12)$

Calculate AW for each MARR value. The decision is sensitive; it changes at 6%.

MARR	AW_1	AW_2	Select
4%	$–2318	$–2234	2
6	–2444	–2448	1
8	–2573	–2673	1

(b) Spreadsheet analysis: Use the PMT function to find AW over the life of each system.



	A	B	C	D	E	F	G
3	Year	System 1	System 2				
4	0	-10,000	-17,000	MARR	AW of 1	AW of 2	Select
5	1	-600	-150	4%	($2,318)	($2,234)	2
6	2	-600	-150	6%	($2,444)	($2,448)	1
7	3	-600	-150	8%	($2,573)	($2,672)	1
8	4	-2350	-150				
9	5	-600	-150				
10	6	-600	-3150				
11	7	-600	-150				
12	8	-700	-150				
13	9		-150				
14	10		-150				
15	11		-150				
16	12		-450				

18.7 (a) Breakeven number of vacation days per year is x.

$$AW_{cabin} = -130{,}000(A/P,10\%,10) + 145{,}000(A/F,10\%,10) - 1500 + 150x - (50/30)(1.20)x$$

$$AW_{trailer} = -75{,}000(A/P,10\%,10) + 20{,}000(A/F,10\%,10) - 1{,}750 + 125x - [300/30(0.6)](1.20)x$$

$$AW_{cabin} = AW_{trailer}$$

$$-130{,}000(0.16275) + 145{,}000(0.06275) - 1500 + 148x = -75{,}000(0.16275) + 20{,}000(0.06275) - 1750 + 105x$$

$$-13{,}558.75 + 148x = -12{,}701.25 + 105x$$

$43x = 857.5$ $\quad$ $x = 19.94$ days $\quad$ (Use x = 20 days per year)

(b) AW sensitivity analysis is performed for 12, 16, 20, 24, and 28 days.

$$AW_{cabin} = -13{,}558.75 + 148x$$
$$AW_{trailer} = -12{,}701.25 + 105x$$

Days, x	AW_{cabin}	$AW_{trailer}$	Selected
12	$-11,783	$-11,441	Trailer
16	-11,191	-11,021	Trailer
20	-10,599	-10,601	Cabin
24	-10,007	-10,181	Cabin
28	- 9415	- 9761	Cabin

Each pair of AW values are close to each other, especially for x = 20, which is the breakeven point.

(c) The trailer alternative. Select the alternative with the lower variable cost, since the variable term is positive, not a cost.

18.8 (a and b) Bond interest = b(50,000)/4 = $12,500(b), where b = 5%, 7%, and 9%. Use trial and error (a) or the IRR function (b) to find i* in the PW relation:

$$0 = -42{,}000 + (12{,}500b)(P/A,i^*,60) - 50{,}000(P/F,i^*,60)$$

Rate, b	Interest per quarter	i*/quarter	Nominal i* per year
5%	$625	1.67%	6.68%
7%	875	2.24	8.96
9%	1125	2.80	11.20

18.9 <u>6 years</u>

PW = –30,000 + 3500(P/A,8%,6) + 25,000(P/F,8%,6)
= –30,000 + 3500(4.6229) + 25,000(0.6302)
= $1935

<u>10 years</u>

PW = –30,000 + 3500(P/A,8%,10) + 15,000(P/F,8%,10)
= –30,000 + 3500(6.7101) + 15,000)0.4632)
= $433

<u>12 years</u>

PW = –30,000 + 3500(P/A,8%,12) + 8000(P/F,8%,12)
= $–447

The decision is sensitive to the life of the investment.

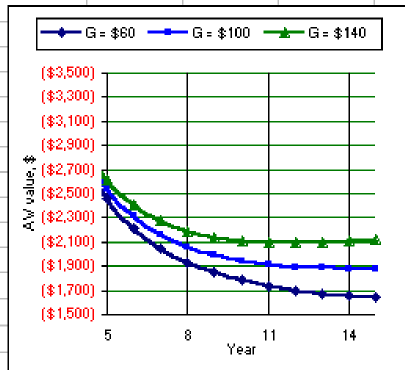
18.10 At i = 5%, find the AW value for n from 1 to 15. AW = –8000(A/P,5%,n) – 500 – G(G/A,5%,n)

For spreadsheet analysis, use the PMT functions to obtain the AW for each n value for each G amount. The table below includes the analysis for G = $60, $100 and $140. As an example, the cell entries for G = $-60 are:

For n = 1 year		For n = 12 years	
A5:	1	A16:	12
B5:	$–500	B16:	B15 – 60
C5:	= -PMT(5%,1,NPV(5%,B5:B5)+B1)	C16:	= -PMT(5%,12,NPV(5%,B5:B16)+B1)

Microsoft Excel - Prob 18.10

	A	B	C	D	E	F	G
1	P =	($8,000)	i% =	5%			
2	G =	$ 60		$ 100		$ 140	
3			AW for		AW for		AW for
4	Year	AOC	G = $60		G = $100		G = $140
5	1	-500	($8,900)	-500	($8,900)	-500	($8,900)
6	2	-560	($4,832)	-600	($4,851)	-640	($4,871)
7	3	-620	($3,496)	-700	($3,534)	-780	($3,573)
8	4	-680	($2,842)	-800	($2,900)	-920	($2,958)
9	5	-740	($2,462)	-900	($2,538)	-1060	($2,614)
10	6	-800	($2,218)	-1000	($2,312)	-1200	($2,406)
11	7	-860	($2,051)	-1100	($2,163)	-1340	($2,275)
12	8	-920	($1,932)	-1200	($2,062)	-1480	($2,192)
13	9	-980	($1,846)	-1300	($1,993)	-1620	($2,140)
14	10	-1040	($1,782)	-1400	($1,946)	-1760	($2,110)
15	11	-1100	($1,734)	-1500	($1,915)	-1900	($2,095)
16	12	-1160	($1,698)	-1600	($1,895)	-2040	($2,092)
17	13	-1220	($1,671)	-1700	($1,884)	-2180	($2,097)
18	14	-1280	($1,651)	-1800	($1,880)	-2320	($2,108)
19	15	-1340	($1,637)	-1900	($1,880)	-2460	($2,124)



Sheet1 / Sheet2 / Sheet3 / Sheet4 / Sheet5 / Sheet6 / Sheet7 / Sheet8

Results from columns C, E, and G are:

G	n*	AW
$60	15	$1637
100	14	1880
140	12	2092

The AW curves are quite flat; there are only a few dollars difference for the various n values around the n* value for each gradient value. The plot clearly shows this.

18.11 The PW relations are

$$PW_A = -P_A + (R_A - AOC_A)(P/A,20\%,5) + 50{,}000(P/F,20\%,5)$$

$$PW_B = -P_B + (R_B - AOC_B)(P/A,20\%,5) + 37{,}000(P/F,20\%,5)$$

Tabular results are presented below.

(a) First cost

Variation	A Value	A PW_A	B Value	B PW_B
–50%	$250,000	$–5610	$187,500	$–23,100
0.00	500,000	–255,610	375,000	–210,600
100%	1,000,000	–755,610	750,000	–585,600

(b) AOC

Variation	A Value	A PW_A	B Value	B PW_B
–50%	$37,500	$–143,463	$40,000	$–90,976
0.00	75,000	–255,610	80,000	–210,600
100%	150,000	–479,905	160,000	–449,848

(c) Revenue

Variation	A Value	A PW_A	B Value	B PW_B
–50%	$75,000	$–479,905	$65,000	$–404,989
0.00	150,000	–255,610	130,000	–210,600
100%	300,000	+192,980	260,000	+178,178

18.12 (a) Purchase price

Variation	Value, P	ROR	
–25%	$18,750	10.53%	
0.00	25,000	1.91%	(IRR function)
+25%	31,250	–4.47%	

$$0 = P - 5500(P/F,i,1) - 1500(P/F,i,2) - 1300(P/F,i,3) + 35{,}000(P/F,i,3)$$

Year	0	1	2	3
Cash flow, $	–P	–5500	–1500	33,700

(b) Selling price

Variation	Salvage, S	ROR
–25%	$26,250	–8.74%
0.00	35,000	1.91%
+25%	43,750	10.83%

(IRR function)

$$0 = -25{,}000 - 5500(P/F,i,1) - 1500(P/F,i,2) - 1300(P/F,i,3) + S(P/F,i,3)$$

Year	0	1	2	3
Cash flow, $	–25,000	–5500	–1500	S–1300

18.13 (a) First cost

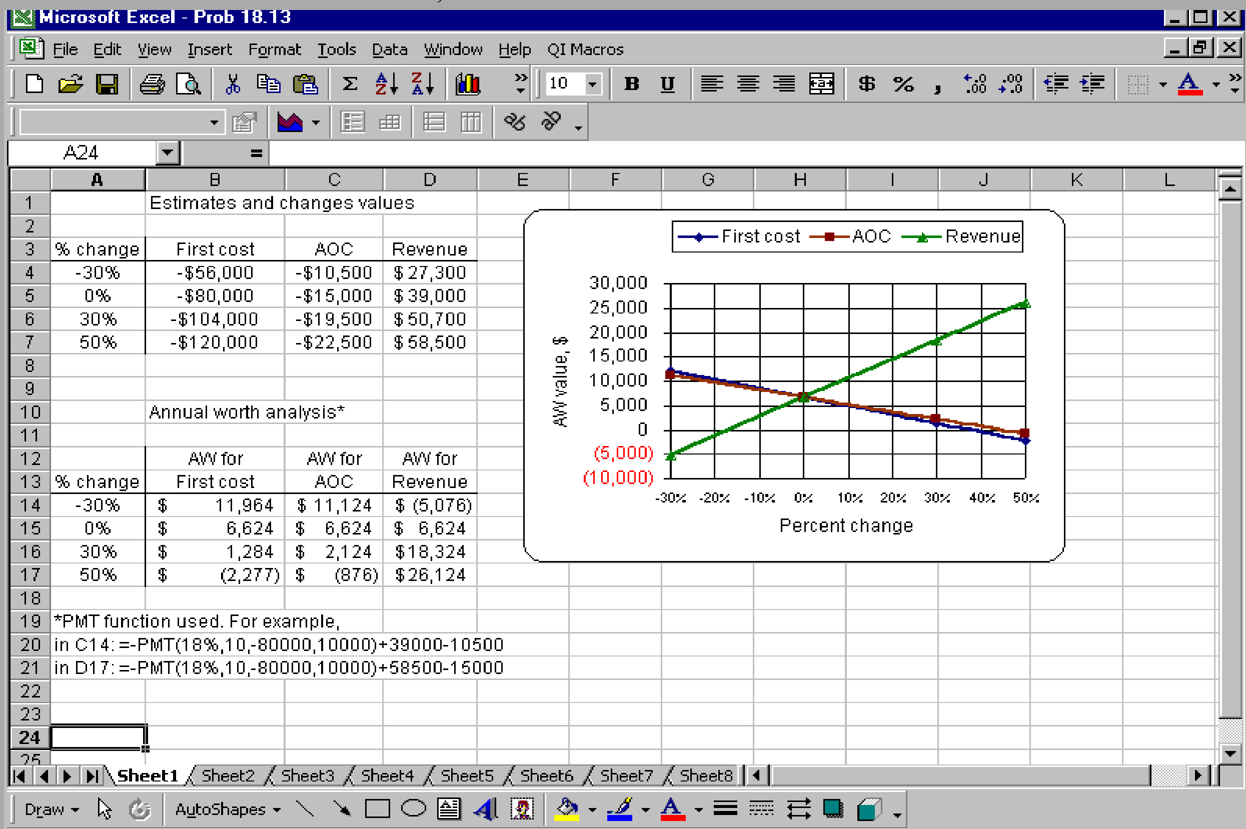
$$AW = -P(A/P,18\%,10) + 10{,}000(A/F,18\%,10) + 24{,}000$$
$$= -P(0.22251) + 24{,}425$$

(b) AOC

$$AW = -80{,}000(A/P,18\%,10) + 10{,}000(A/F,18\%,10) - AOC + 39{,}000$$
$$= -AOC + 21{,}624$$

(c) Revenue

$$AW = -80{,}000(A/P,18\%,10) + 10{,}000(A/F,18\%,10) - 15{,}000 + Revenue$$
$$= -32{,}376 + Revenue$$



Estimates and changes values

% change	First cost	AOC	Revenue
-30%	-$56,000	-$10,500	$27,300
0%	-$80,000	-$15,000	$39,000
30%	-$104,000	-$19,500	$50,700
50%	-$120,000	-$22,500	$58,500

Annual worth analysis*

% change	AW for First cost	AW for AOC	AW for Revenue
-30%	$ 11,964	$ 11,124	$ (5,076)
0%	$ 6,624	$ 6,624	$ 6,624
30%	$ 1,284	$ 2,124	$18,324
50%	$ (2,277)	$ (876)	$26,124

*PMT function used. For example,
in C14: =-PMT(18%,10,-80000,10000)+39000-10500
in D17: =-PMT(18%,10,-80000,10000)+58500-15000

18.14 PW calculates the amount you should be willing to pay now. Plot PW versus ± 30% changes in (a), (b) and (c) on one graph.

(a) Face value, P

$$PW = P(P/F,4\%,20) + 450(P/A,4\%,20)$$
$$= P(0.4564) + 6116$$

(b) Dividend rate, b

$$PW = 10{,}000(P/F,4\%,20) + (10{,}000/2)(b)(P/A,4\%,20)$$
$$= 10{,}000(0.4564) + b(5000)(13.5903)$$
$$= 4564 + b(67{,}952)$$

(c) Nominal rate, r

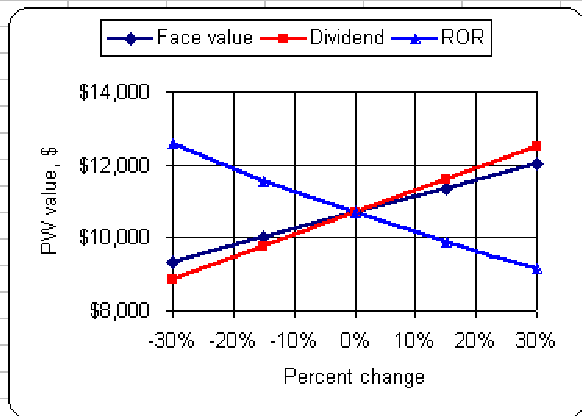
$$PW = 10{,}000(P/F,r,20) + 450(P/A,r,20)$$

Microsoft Excel - Prob 18.14

% change	Face value	Dividend	ROR
-30%	$ 7,000	$ 315.00	2.8%
-15%	$ 8,500	$ 382.50	3.4%
0%	$ 10,000	$ 450.00	4.0%
15%	$ 11,500	$ 517.50	4.6%
30%	$ 13,000	$ 585.00	5.2%

Present worth analysis*

% change	PW for Face value	PW for Dividend	PW for ROR
-30%	$ 9,310	$ 8,845	$ 12,577
-15%	$ 9,995	$ 9,762	$ 11,578
0%	$ 10,680	$ 10,680	$ 10,680
15%	$ 11,364	$ 11,597	$ 9,871
30%	$ 12,049	$ 12,514	$ 9,142



PV function used. For example:
in B17: =-PV(4%,20,450,7000)
in D21: =-PV(5.2%,20,450,10000)

18.15 (a) 50 days

<u>Plan 1 - Purchase</u>

<u>Opt: $0.40 per ton (AOC = $2000)</u>

$$AW = -6000(A/P,12\%,5) - 0.40(100)(50)$$
$$= -6000(0.27741) - 2000$$
$$= \$-3664$$

<u>ML: $0.50 per ton (AOC = $2500)</u>

$$AW = -6000(A/P,12\%,5) - 0.50(100)(50)$$
$$= -6000(0.27741) - 2{,}500$$
$$= \$-4164$$

18.15 (cont)

Pess: \$0.75 per ton (AOC = \$3750)

$$\begin{aligned} AW &= -6000(A/P,12\%,5) - 0.75(100)(50) \\ &= -6000(0.27741) - 3750 \\ &= \$-5414 \end{aligned}$$

Plan 2 - Lease

Opt: \$1800 lease

$$AW = -1800 - 50(8)(5.00) = \$-3800$$

ML: \$2500 lease

$$AW = -2500 - 50(8)(5.00) = \$-4500$$

Pess: \$3200 lease

$$AW = -3200 - 50(8)(5.00) = \$-5200$$

Plan 1 is better for the most likely estimates (\$0.50 and \$2500).

(b) 100 days Plan 1 - Purchase

Opt: \$0.40 per ton (AOC = \$4000)

$$\begin{aligned} AW &= -6000(A/P,12\%,5) - 0.40(100)(100) \\ &= -6000(0.27741) - 4000 \\ &= \$-5664 \end{aligned}$$

ML: \$0.50 per ton (AOC = \$5000)

$$\begin{aligned} AW &= -6000(A/P,12\%,5) - 0.50(100)(100) \\ &= -6000(0.27741) - 5000 \\ &= \$-6664 \end{aligned}$$

Pess: 0.75 per ton (AOC = \$7500)

$$\begin{aligned} AW &= -6000(A/P,12\%,5) - 0.75(100)(100) \\ &= -6000(0.27741) - 7500 \\ &= \$-9164 \end{aligned}$$

Plan 2 - Lease

Opt: \$1800 lease

$$AW = -1800 - 100(8)(5.00) = \$-5800$$

ML: \$2,500 lease

$$AW = -2500 - 100(8)(5.00) = \$-6500$$

Pess: $3,200 lease

$$AW = -3200 - 100(8)(5.00) = \$-7200$$

Plan 2 is better on the basis of the most likely estimates.

18.16 Water/wastewater cost = (0.12 + 0.04) per 1000 liters
= 0.16 per 1000 liters

Spray Method

Pessimistic - 100 liters

Water required = 10,000,000(100) = 1.0 billion

$$AW = -(0.16/1000)(1.00 \times 10^9) = \$-160,000$$

Most Likely - 80 liters

Water required = 10,000,000(80) = 800 million

$$AW = -(0.16/1000)(800,000,000) = \$-128,000$$

Optimistic - 40 liters

Water required = 10,000,000(40) = 400 million

$$AW = -(0.16/1000)(400,000,000) = \$-64,000$$

Immersion Method

$$\begin{aligned} AW &= -10,000,000(40)(0.16/1000) - 2000(A/P,15\%,10) - 100 \\ &= -64,000 - 2000(0.19925) - 100 \\ &= \$-64,499 \end{aligned}$$

The immersion method is cheaper than the spray method, unless the optimistic estimate of 40 L is actually correct.

18.17 (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

$$\begin{aligned} PW_M &= -100,000 + 15,000(P/A,10\%,22) \\ &= -100,000 + 15,000(8.7715) \\ &= \$31,573 \end{aligned}$$

$$\begin{aligned} PW_Q &= -110,000 + 19,000(P/A,10\%,22) \\ &= -110,000 + 19,000(8.7715) \\ &= \$56,659 \end{aligned}$$

(c) Plot the PW values for each value of MARR and life. Plan M always has a lower PW value, so it is not accepted and plan Q is.

18.18 $$\begin{aligned} E(flow_N) &= 0.15(100) + 0.75(200) + 0.10(300) \\ &= 195 \text{ barrels/day} \end{aligned}$$

$$\begin{aligned} E(flow_E) &= 0.35(100) + 0.15(200) + 0.45(300) + 0.05(400) \\ &= 220 \text{ barrels/day} \end{aligned}$$

18.19 (a) E(time) = (1/4)(10 + 20 + 30 + 70) = 32.5 seconds

(b) E(time) = (1/3)(10 + 20 + 30) = 20 seconds

Yes, the 70 second estimate does increase the mean significantly.

18.20

n	1	2	3	4
Y	3	9	27	81

$$\begin{aligned} E(Y) &= 3(0.4) + 9(0.3) + 27(0.233) + 81(0.067) \\ &= 15.618 \end{aligned}$$

18.21 Solve for the low AOC from E(AOC)

$$E(AOC) = 4575 = 2800(0.25) + (\text{high AOC})(0.75)$$
$$\text{High AOC} = \$5167$$

18.22 $E(i) = 1/20[(-8)(1) + (-5)(1) + 0(5) + ... + 15(3)]$
$= 103/20 = 5.15\%$

18.23 $E(AW) = 0.15(300{,}000 – 25{,}000) + 0.7(50{,}000) = \$76{,}250$

18.24 (a) The subscripts identify the series by probability.

$$\begin{aligned} PW_{0.5} &= –5000 + 1000(P/A,20\%,3) \\ &= –5000 + 1000(2.1065) \\ &= \$–2894 \end{aligned}$$

$$\begin{aligned} PW_{0.2} &= –6000 + 500(P/F,20\%,1) + 1500(P/F,20\%,2) + 2000(P/F,20\%,3) \\ &= –6000 + 500(0.8333) + 1500(0.6944) + 2000(0.5787) \\ &= \$–3384 \end{aligned}$$

$$\begin{aligned} PW_{0.3} &= –4000 + 3000(P/F,20\%,1) + 1200(P/F,20\%,2) – 800(P/F,20\%,3) \\ &= –4000 + 3000(0.8333) + 1200(0.6944) – 800(0.5787) \\ &= \$–1130 \end{aligned}$$

$$\begin{aligned} E(PW) &= (PW_{0.5})(0.5) + (PW_{0.2})(0.2) + (PW_{0.3})(0.3) \\ &= –2894(0.5) – 3384(0.2) – 1130(0.3) \\ &= \$–2463 \end{aligned}$$

(b) $$\begin{aligned} E(AW) &= E(PW)(A/P,20\%,3) \\ &= –2463(0.47473) \\ &= \$–1169 \end{aligned}$$

18.25 Determine E(AW) after calculating E(revenue).

$$\begin{aligned} E(\text{revenue}) &= 3[\text{no. days})(\text{no. climbers})(\text{income/climbers})](\text{probability}) \\ &= [(120)(350)(5)](0.3) + [(120)(350)(5) + 30(100)(5)](0.5) \\ &\quad + [(120\ )(350)(5) + (45)(100)(5)](0.2) \\ &= 63{,}000 + 112{,}500 + 46{,}500 \\ &= \$222{,}000 \end{aligned}$$

$$E(AW) = -375{,}000(A/P,12\%,10) - 25{,}000[(P/F,12\%,4) + (P/F,12\%,8)](A/P,12\%,10) - 56{,}000 + 222{,}000$$
$$= -375{,}000(0.17698) - 25{,}000[(0.6355) + (0.4039)](0.17698) + 166{,}000$$
$$= \$95{,}034$$

The mock mountain should be constructed.

18.26 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.

18.27 Certificate of Deposit

Rate of return = 6.35% (from problem statement)

Stocks

Stock 1: $-5000 + 250(P/A,i\%,4) + 6800(P/F,i\%,5) = 0$
is the i* relation.
i* = 10.07% (RATE function)

Stock 2: $-5000 + 600(P/A,i\%,4) + 4000(P/F,i\%,5) = 0$
$i^* = 6.36\%$ (RATE function)

$E(i) = 10.07(0.5) + 6.36(0.5) = 8.22\%$

Real Estate

Rate of return with Prob = 0.3
$-5{,}000 - 425(P/A,i\%,4) + 9500(P/F,i\%,5) = 0$
$i^* = 8.22\%$

Rate of return with Prob. 0.5
$-5000 + 7200(P/F,i\%,5) = 0$
$(P/F,i\%,5) = 0.6944$
$i^* = 7.57\%$

Rate of return with Prob. 0.2
$-5000 + 500(P/A,i\%,4) + 100(P/G,i\%,4) + 5200(P/F,i\%,5) = 0$
$i^* = 11.34\%$

$E(i) = 8.22(0.3) + 7.57(0.5) + 11.34(0.2)$
$= 8.52\%$

Invest in real estate for the highest E(rate of return) of 8.52%.

18.28 (a) Calculate fraction in equity times i on equity from graph.

$E(i) = 0.3(\text{i on 20-80}) + 0.5(\text{i on 50-50}) + 0.2(\text{i on 80-20})$
$= 0.3(7\%) + 0.5(9\%) + 0.2(11.5)$
$= 8.9\%$

(b) (Fraction of pool)($1 million)(fraction of D-E in equity)
Amount = 0.3($1 mil)(0.8) + 0.5($1 mil)(0.5) + 0.2($1 mil)(0.2)
= 0.3 (800,000) + 0.5(500,000) + 0.2(200,000)
= 240,000 + 250,000 + 40,000
= $530,000
The FW is calculated using the correct i rate for each equity amount.

$FW = 240{,}000(F/P,7\%,10) + 250{,}000(F/P,9\%,10) + 40{,}000(F/P,11.5\%,10)$

$= 240{,}000(1.9672) + 250{,}000(2.3674) + 40{,}000(2.9699)$
$= \$1{,}182{,}755$

(c) Use Eq. [14.9] to determine the real i. The graph rates are actually i_f values.

$$\begin{aligned} \text{at } i_f = 7\%: i &= (i_f - f)/(1 + f) \\ &= (0.07 - 0.045)/(1 + 0.045) \\ &= 0.0239 \qquad (2.39\%) \end{aligned}$$

$$\text{at } i_f = 9\%: i = (0.09 - 0.045)/1.045 = 0.043 \qquad (4.3\%)$$

$$\text{at } i_f = 11.5\%: i = (0.115 - 0.045)/1.045 = 0.067 \qquad (6.7\%)$$

This is case 2 in Sec. 14.3. Use Eq. [14.8].

$$\begin{aligned} FW &= 1{,}182{,}755/(1.045)^{10} \\ &= 1{,}182{,}755/1.55297 \\ &= \$761{,}608 \end{aligned}$$

Alternatively, find FW at the real i for each equity amount.

$$\begin{aligned} FW &= 240{,}000(F/P{,}2.39\%{,}10) + 250{,}000(F/P{,}4.3\%{,}10) \\ &\qquad +40{,}000(F/P{,}6.7\%{,}10) \\ &= 240{,}000(1.26641) + 250{,}000(1.5238) + 40{,}000(1.9127) \\ &= \$303{,}939 + 380{,}876 + 76{,}508 \\ &+ \$761{,}323 \qquad \text{(Rounding of i makes the difference)} \end{aligned}$$

18.29 AW = annual loan payment + (damage) x P(rainfall amount or greater)

The subscript on AW indicates the rainfall amount.

$$\begin{aligned} AW_{2.0} &= -200{,}000(A/P{,}6\%{,}10) + (-50{,}000)(0.3) \\ &= -200{,}000(0.13587) -50{,}000(0.3) \\ &= \$-42{,}174 \end{aligned}$$

$$\begin{aligned} AW_{2.25} &= -225{,}000(A/P{,}6\%{,}10) + (-50{,}000)(0.1) \\ &= -300{,}000(0.13587) -50{,}000(0.1) \\ &= \$-35{,}571 \end{aligned}$$

$$\begin{aligned} AW_{2.5} &= -300{,}000(A/P{,}6\%{,}10) + (-50{,}000)(0.05) \\ &= -350{,}000(0.13587) -50{,}000(0.05) \\ &= \$-43{,}261 \end{aligned}$$

$$\begin{aligned} AW_{3.0} &= -400{,}000(A/P{,}6\%{,}10) + (-50{,}000)(0.01) \\ &= -400{,}000(0.13587) -50{,}000(0.01) \\ &= \$-54{,}848 \end{aligned}$$

$$\begin{aligned} AW_{3.25} &= –450{,}000(A/P,6\%,10) + (–50{,}000)(0.005) \\ &= –450{,}000(0.13587) –50{,}000(0.005) \\ &= \$–61{,}392 \end{aligned}$$

Build a wall to protect against a rainfall of 2.25 inches with an expected AW of \$–35,571.

18.30 Compute the expected value for each outcome and select the minimum for D3.

Top node: 0.2(55) + 0.35(–30) + 0.45(10) = 5.0

Bottom node: 0.4(–17) + 0.6(0) = –6.8

Indicate 5.0 and –6.8 in ovals and select the top branch with E(value) = 5.0.

18.31 Maximize the value at each decision node.

<u>D3</u>: Top: E(value) = \$30
Bottom: E(value) = 0.4(100) + 0.6(–50) = \$10

Select top at D3 for \$30

<u>D1</u>: Top: 0.9(D3 value) + 0.1(final value)
0.9(30) + 0.1(500) = \$77
Value at D1 = 77-50 = \$27
Bottom: 90 – 80 = \$10

Select top at D1 for \$27

<u>D2</u>: 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)

18.32 Calculate the E(PW) in year 3 and select the largest expected value. In \$1000 terms:

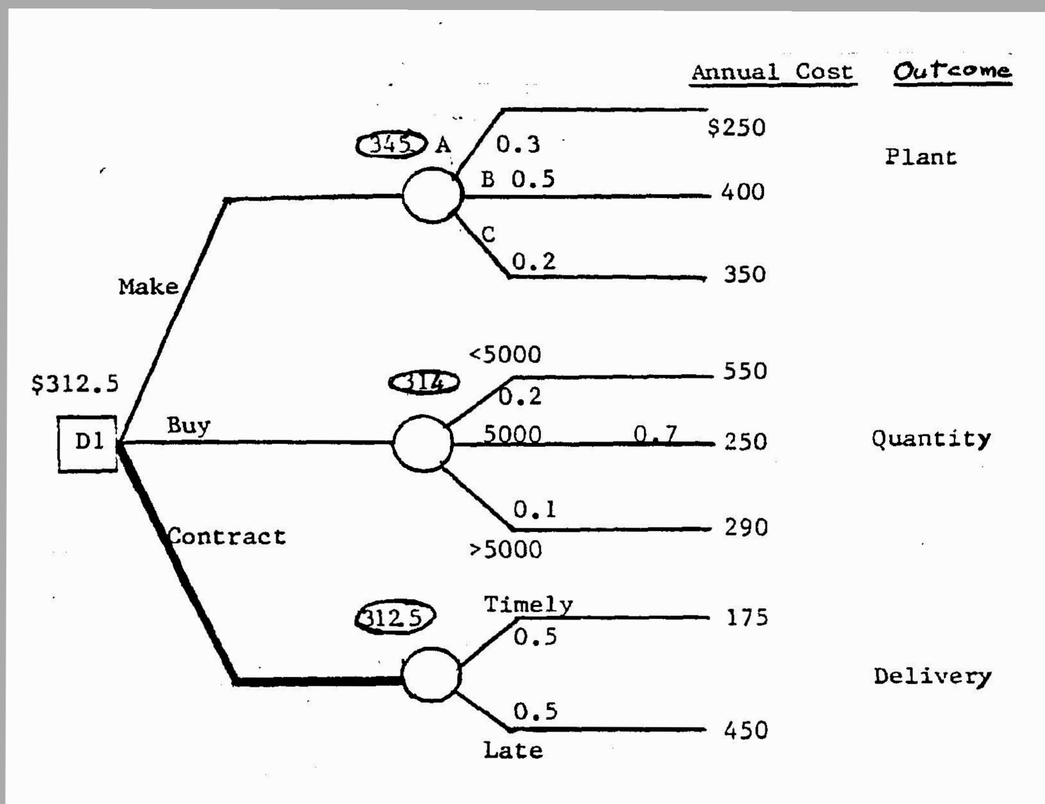
$$E(\text{PW of D4,x}) = -200 + 0.7[50(P/A,15\%,3)] + 0.3[40(P/F,15\%,1) + 30(P/F,15\%,2) + 20(P/F,15\%,3)]$$
$$= -98.903 \qquad (\$-98{,}903)$$

$$E(\text{PW of D4,y}) = -75 + 0.45[30(P/A,15\%,3) + 10(P/G,15\%,3)] + 0.55[30(P/A,15\%,3)]$$
$$= 2.816 \qquad (\$2816)$$

$$E(\text{PW of D4,z}) = -350 + 0.7[190(P/A,15\%,3) - 20(P/G,15\%,3)] + 0.3[-30(P/A,15\%,3)]$$
$$= -95.880 \qquad (\$-95{,}880)$$

Select decision branch y; it has the largest E(PW).

18.33 Select the minimum E(cost) alternative. (All dollar values are times \$-1000).



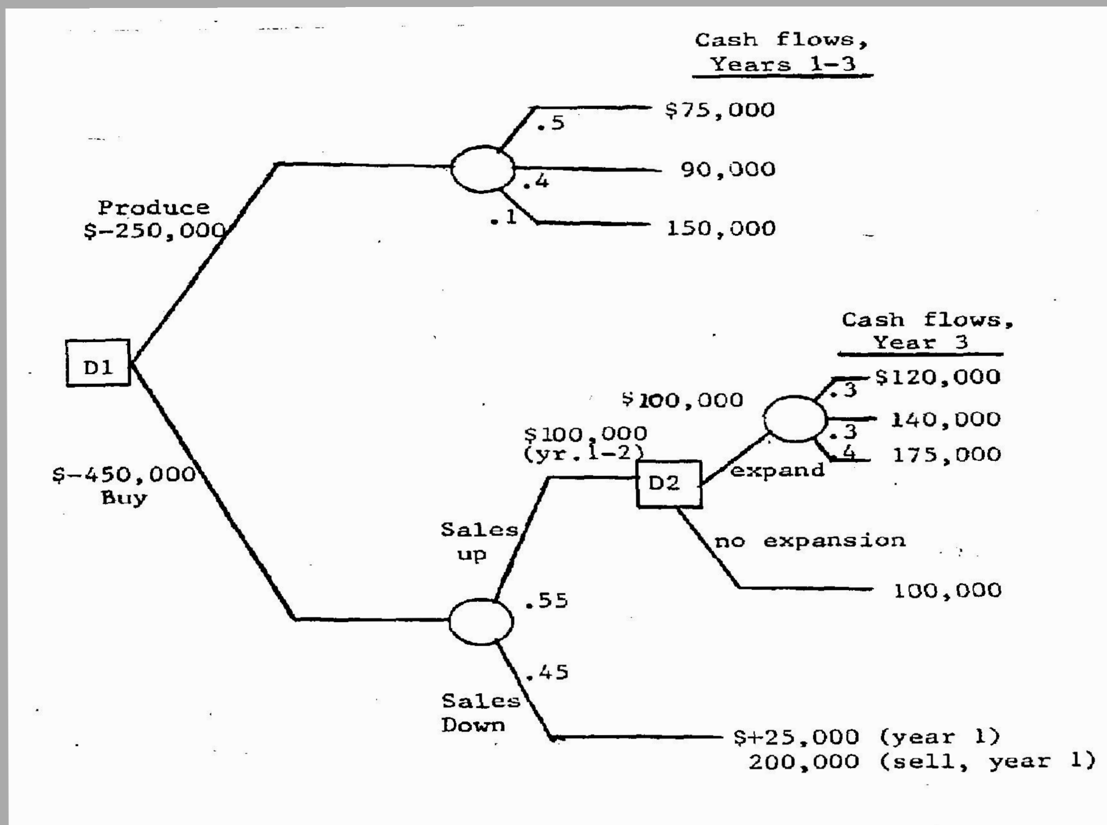
Make: E(cost of plant) = 0.3(250) + 0.5(400) + 0.2(350)
= \$345 (\$345,000)

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.

18.34 (a) Construct the decision tree.



(b) At D2 compute PW of cash flows and E(PW) using probability values.

Expansion option

(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

18.34 (cont) No expansion option

(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 foldback 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 than buy.

(d) The return would increase on the initial investment, but would increase faster for the produce option.

Extended Exercise Solution

1. Relations are developed here for hand solution.

MARR = 8%

$$
\begin{aligned}
PW_A &= -10{,}000 + 1000(P/F,8\%,40) - 500(P/A,8\%,40)\\
&= -10{,}000 + 1000(0.0460) - 500(11.9246)\\
&= \$-15{,}916
\end{aligned}
$$

$$
\begin{aligned}
PW_B &= -30{,}000 + 5000(P/F,8\%,40) - 100(P/A,8\%,40) - 5000\\
&\quad - 200(P/F,8\%,20) - 5000(P/F,8\%,20) - 200(P/F,8\%,40) - 200(P/A,8\%,40)\\
&= -35{,}000 + 4800(P/F,8\%,40) - 300(P/A,8\%,40) - 5200(P/F,8\%,20)\\
&= -35{,}000 + 4800(0.0460) - 300(11.9246) - 5200(0.2145)\\
&= \$-39{,}472
\end{aligned}
$$

MARR = 10%

$$
\begin{aligned}
PW_A &= -10{,}000 + 1000(P/F,10\%,40) - 500(P/A,10\%,40)\\
&= -10{,}000 + 1000(0.0221) - 500(9.7791)\\
&= \$-14{,}867
\end{aligned}
$$

$$
\begin{aligned}
PW_B &= -30{,}000 + 5000(P/F,10\%,40) - 100(P/A,10\%,40) - 5000\\
&\quad - 200(P/F,10\%,20) - 5000(P/F,10\%,20) - 200(P/F,10\%,40)\\
&\quad - 200(P/A,10\%,40)\\
&= -35{,}000 + 4800(P/F,10\%,40) - 300(P/A,10\%,40) - 5200(P/F,10\%,20)\\
&= -35{,}000 + 4800(0.0221) - 300(9.7791) - 5200(0.1486)\\
&= \$-38{,}600
\end{aligned}
$$

MARR = 15%

$$
\begin{aligned}
PW_A &= -10{,}000 + 1000(P/F,15\%,40) - 500(P/A,15\%,40)\\
&= -10{,}000 + 1000(0.0037) - 500(6.6418)\\
&= \$-13{,}317
\end{aligned}
$$

$$
\begin{aligned}
PW_B &= -30{,}000 + 5000(P/F,15\%,40) - 100(P/A,15\%,40) - 5000\\
&\quad -200(P/F,15\%,20) - 5000(P/F,15\%,20) - 200(P/F,15\%,40)\\
&\quad -200(P/A,15\%,40)\\
&= -35{,}000 + 4800(P/F,15\%,40) - 300(P/A,15\%,40) - 5200(P/F,15\%,20)\\
&= -35{,}000 + 4800(0.0037) - 300(6.6418) - 5200(0.0611)\\
&= \$-37{,}293
\end{aligned}
$$

Not very sensitive.

2. <u>Expanding economy</u>

$$n_A = 40(0.80) = 32 \text{ years}$$
$$n_1 = 40(0.80) = 32 \text{ years}$$
$$n_2 = 20(0.80) = 16 \text{ years}$$

$$\begin{aligned} PW_A &= -10{,}000 + 1000(P/F,10\%,32) - 500(P/A,10\%,32) \\ &= -10{,}000 + 1{,}000(0.0474) - 500(9.5264) \\ &= \$-14{,}716 \end{aligned}$$

$$\begin{aligned} PW_B &= -30{,}000 + 5000(P/F,10\%,32) - 100(P/A,10\%,32) - 5000 \\ &\quad -200(P/F,10\%,16) - 5000(P/F,10\%,16) - 200(P/F,10\%,32) \\ &\quad -200(P/A,10\%,32) \\ &= -35{,}000 + 4800(P/F,10\%,32) - 300(P/A,10\%,32) - 5200(P/F,10\%,16) \\ &= -35{,}000 + 4800(0.0474) - 300(9.5264) - 5200(0.2176) \\ &= \$-38{,}762 \end{aligned}$$

<u>Expected economy</u>

$PW_A = \$-14{,}876$ (from #1)

$PW_B = \$-38{,}600$ (from #1)

<u>Receding economy</u>

$$n_A = 40(1.10) = 44 \text{ years}$$
$$n_1 = 40(1.10) = 44 \text{ years}$$
$$n_2 = 20(1.10) = 22 \text{ years}$$

$$\begin{aligned} PW_A &= -10{,}000 + 1000(P/F,10\%,44) - 500(P/A,10\%,44) \\ &= -10{,}000 + 1000(0.0154) - 500(9.8461) \\ &= \$-14{,}908 \end{aligned}$$

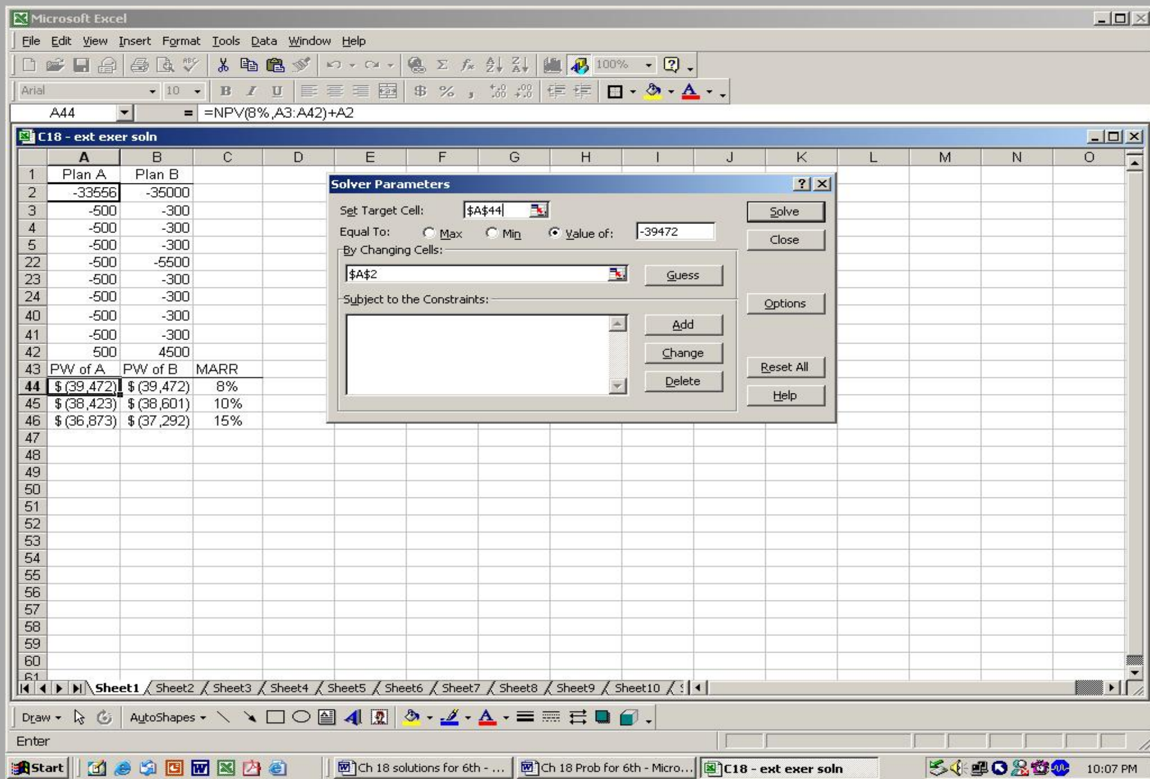
$$\begin{aligned} PW_B &= -30{,}000 + 5000(P/F,10\%,44) - 100(P/A,10\%,44) - 5000 \\ &\quad - 200(P/F,10\%,22) - 5000(P/F,10\%,22) - 200(P/F,10\%,44) \\ &\quad - 200(P/F,10\%,44) \\ &= -35{,}000 + 4800(P/F,10\%,44) - 300(P/A,10\%,44) - 5200(P/F,10\%,22) \\ &= -35{,}000 + 4800(0.0154) - 300(9.8461) - 5200(0.1228) \\ &= \$-38{,}519 \end{aligned}$$

Not very sensitive.

3. In all cases, plan A has the best PW.

4. Use SOLVER to find the breakeven values of P_A for the three MARR values of 8%, 10%, and 15% per year.

For MARR = 8%, the SOLVER screen is below.



Breakeven values are:

MARR	Breakeven P_A
8%	$–33,556
10	–33,734
15	–33,975

The P_A breakeven value is not sensitive, but all three outcomes are over 3X the $10,000 estimated first cost for plan A.

Case Study Solution

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

   Therefore, 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

$$\text{Decrease} = 69.63 - 66.15$$
$$= \$3.48 \text{ or } 5\%$$

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.

Chapter 19

More on Variation and Decision Making Under Risk

Solutions to Problems

19.1 (a) Continuous (assumed) and uncertain – no chance statements made.
(b) Discrete and risk – plot units vs. chance as a continuous straight line between 50 and 55 units.
(c) 2 variables: first is discrete and certain at \$400; second is continuous for ≥ \$400, but uncertain (at this point). More data needed to assign any probabilities.
(d) Discrete variable with risk; rain at 20%, snow at 30%, other at 50%.

19.2 Needed or assumed information to be able 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.

19.3 (a) N is discrete since only specific values are mentioned; i is continuous from 0 to 12.
(b) The P(N), F(N), P(i) and F(i) are 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)	.22	.10	.12	.42	.08	.06
F(i)	.22	.32	.44	.86	.94	1.00

(c) $P(N = 1 \text{ or } 2) = P(N = 1) + P(N = 2)$
$= 0.56 + 0.26 = 0.82$
or
$F(N \le 2) - F(N \le 0) = 0.94 - 0.12 = 0.82$

$P(N \ge 3) = P(N = 3) + P(N \ge 4) = 0.06$

(d) $P(7\% \le i \le 11\%) = P(6.01 \le i \le 12)$

$= 0.42 + 0.08 + 0.06 = 0.56$

or

$F(i \le 12\%) - F(i \le 6\%) = 1.00 - 0.44$

$= 0.56$

19.4 (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 cents per ticket

19.5 (a) $P(N) = (0.5)^N \qquad N = 1,2,3,...$

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) $P(N = 1, 2 \text{ or } 3) = F(N \le 3) = 0.875$

19.6 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.

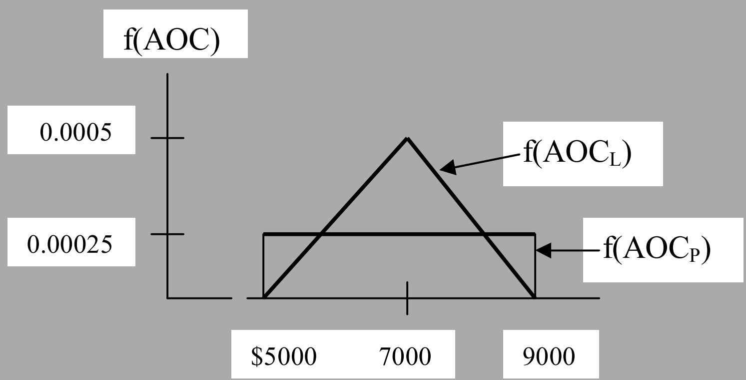
The $f(S_P)$ is symmetric around $2500.
f(M) = f(2500) = 2/(1000) = 0.002 is the probability at $2500.

There is no S_L distribution

AOC

$f(AOC_P) = 1/(9000–5000) = 0.00025$

$f(AOC_L)$ is triangular with:
f(7000) = 2/(9000–5000) = 0.0005

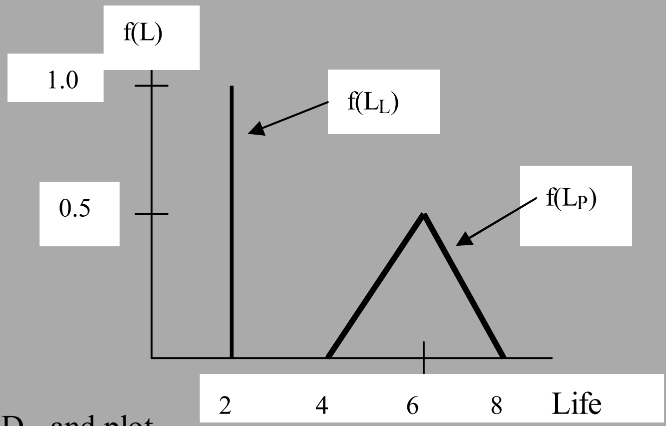


Life, L

$f(L_P)$ is triangular with mode at 6.

$f(6) = 2/(8-4) = 0.5$

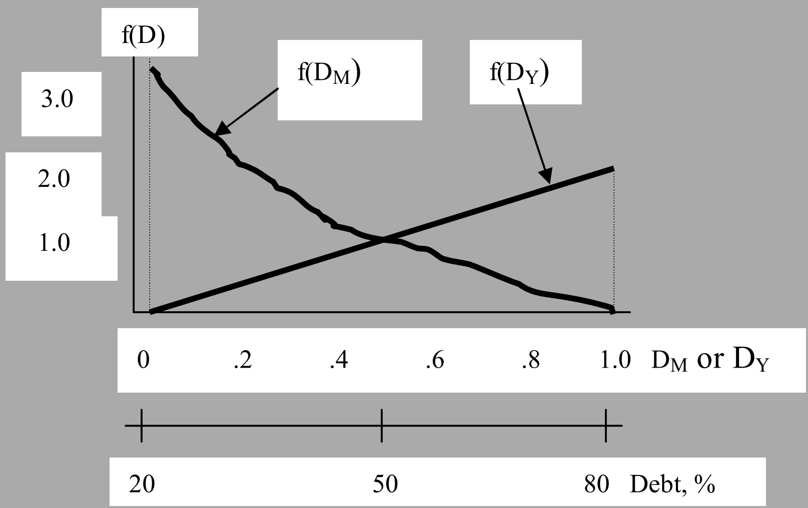
The value L_L is certain at 2 years.



19.7 (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.

19.8 (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) $P(6 \le X \le 10) = F(10) - F(3) = 1.0 - 0.6 = 0.4$

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.

19.9 Plot the $F(X_i)$ from Problem 19.8 (a), assign the RN values, use Table 19.2 to obtain 25 sample X values; calculate the sample $P(X_i)$ values and compare them to the stated probabilities in 19.8.

(Instructor note: Point out to students that it is not correct to develop the sample $F(X_i)$ from another sample where some discrete variable values are omitted).

19.10 (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.

19.11 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:

$$F(G = g) = \begin{cases} 0.30 & G=A & 00\text{-}29 \\ 0.70 & G=B & 30\text{-}69 \\ 0.90 & G=C & 70\text{-}89 \\ 1.00 & G=D & 90\text{-}99 \\ 1.00 & G=F & \text{--} \\ 1.00 & G=I & \text{--} \end{cases} \qquad \text{(RNs in last column)}$$

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.

19.12 (a) When RAND( ) was used for 100 values in column A of an Excel spreadsheet, the function AVERAGE(A1:A100) resulted in 0.50750658; very close to 0.5.

RANDBETWEEN(0,1) generates only integer values of 0 or 1. For one sample of 100, the average was 0.48; in another it was exactly 0.50.

(b) For the RAND results, count the number of values in each cell to determine how close it is to 10.

19.13 (a) Use Equations [19.9] and [19.12] or the spreadsheet functions AVERAGE and STDEV.

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	9	1,000,000	9,000	9,000,000
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	7	3,240,000	12,600	22,680,000
2000	10	4,000,000	20,000	40,000,000
	100		134,400	195,120,000

AVERAGE: Xbar = 134,400/100 = 1344.00

$$\text{STDEV:}\quad s^2 = \left[\frac{195{,}120{,}000}{99} - \frac{100}{99}(1344)^2\right]^2$$

$$= (146{,}327.27)^2$$

$$= 382.53$$

(b) Xbar ± 2s is 1344.00 ± 2(382.53) = 578.94 and 2109.06
All values are in the ±2s range.

(c) Plot X versus f. Indicate Xbar and the range Xbar ± 2s on it.

19.14 (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: Xbar = 4.6

Sample variance: $s^2 = \frac{1630}{49} - \frac{50}{49}(4.6)^2 = 11.67$

$s = 3.42$

(b) Xbar ± 1s is 4.6 ± 3.42 = 1.18 and 8.02
25 values, or 50%, are in this range.

Xbar ± 2s is 4.6 ± 6.84 = –2.24 and 11.44
All 50 values, or 100%, are in this range.

19.15 (a) Use Equations [19.15] and [19.16]. Substitute Y for D_Y.

$f(Y) = 2Y$

$$E(Y) = \int_0^1 (Y)2Y dy$$

$$= \left[\frac{2Y^3}{3}\right]_0^1$$

$$= 2/3 - 0 = 2/3$$

$$Var(Y) = \int_0^1 (Y^2)2Y dy - [E(Y)]^2$$

$$= \left[\frac{2Y^4}{4}\right]_0^1 - (2/3)^2$$

$$Var(Y) = \frac{2}{4} - 0 - \frac{4}{9}$$

$$= 1/18 = 0.05556$$

$$\sigma = (0.05556)^{0.5} = 0.236$$

(b) E(Y) ± 2σ is 0.667 ± 0.472 = 0.195 and 1.139

Take the integral from 0.195 to 1.0 only since the variable's upper limit is 1.0.

$$P(0.195 \le Y \le 1.0) = \int_{0.195}^{1} 2Y dy$$

$$= Y^2 \Big|_{0.195}^{1}$$

$$= 1 - 0.038 = 0.962 \qquad (96.2\%)$$

19.16 (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 19.15 to take the integral from 0 to 0.6372.

$$P(0 \le M \le 0.6372) = \int_0^{0.6372} 3(1 - M)^2\, dm$$

$$= 3\int_0^{0.6372} (1 - 2M + M^2)dm$$

$$= 3\left[M - M^2 + 1/3\ M^3\right]_0^{0.6372}$$

$$= 3\left[0.6372 - (0.6372)^2 + 1/3\ (0.6372)^3\right]$$

$$= 0.952 \qquad (95.2\%)$$

19.17 Use Eq. [19.8] where $P(N) = (0.5)^N$

$E(N) = 1(.5) + 2(.25) + 3(.125) + 4(0.625) + 5(.03125) + 6(.015625) + 7(.0078125)$
$\quad + 8(.003906) + 9(.001953) + 10(.0009766) + ..$
$= 1.99+$

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.

19.18 $E(Y) = 3(1/3) + 7(1/4) + 10(1/3) + 12(1/12)$
$= 1 + 1.75 + 3.333 + 1$
$= 7.083$

$\text{Var}(Y) = \sum Y^2P(Y) - [E(Y)]^2$
$= 3^2(1/3) + 7^2(1/4) + 10^2(1/3) + 12^2(1/12) - (7.083)^2$
$= 60.583 - 50.169$
$= 10.414$

$\sigma = 3.227$

$E(Y) \pm 1\sigma$ is $7.083 \pm 3.227 = 3.856$ and 10.310

19.19 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.

19.19 (cont) 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 B4: =INT((.04*A4+6) *100)/10000 converts the RN to i from 0.06 to 0.10. The % designation changes it to an interest rate between 6% and 10%.

Col C: = RAND( )* 100

Col D, cell D4: =INT (8*C4+1600) to convert 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.

Microsoft Excel - Prob 19.19

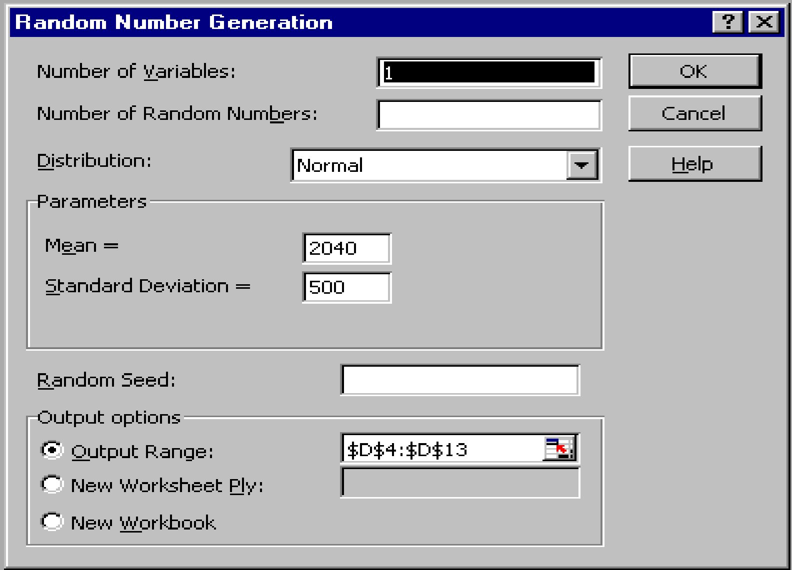
	A	B	C	D	E	F	G
1	RN for i	i	RN for	CFAT,		Annual CFAT	Annual CFAT
2			CFAT	years 7-10		using D4 for CFAT	using D5 for CFAT
3					Year	and B4 for MARR	and B5 for MARR
4	97.0043	9.88%	24.4147	\$ 1,795	0	(\$28,800)	(\$28,800)
5	0.58075	6.02%	24.6312	\$ 1,797	1	\$ 5,400	\$ 5,400
6	42.9306	7.71%	22.558	\$ 1,780	2	\$ 5,400	\$ 5,400
7	42.4314	7.69%	62.8228	\$ 2,102	3	\$ 5,400	\$ 5,400
8	39.5707	7.58%	4.09544	\$ 1,632	4	\$ 5,400	\$ 5,400
9	44.7825	7.79%	42.4287	\$ 1,939	5	\$ 5,400	\$ 5,400
10	29.6074	7.18%	13.6669	\$ 1,709	6	\$ 5,400	\$ 5,400
11	97.9149	9.91%	46.9506	\$ 1,975	7	\$ 1,795	\$ 1,797
12	95.4244	9.81%	44.0617	\$ 1,952	8	\$ 1,795	\$ 1,797
13	84.159	9.36%	51.482	\$ 2,011	9	\$ 1,795	\$ 1,797
14					10	\$ 4,595	\$ 4,597
15							
16				PW of CFAT		(\$866)	\$3,680
17							

=INT((0.04*A13+6)*100)/10000

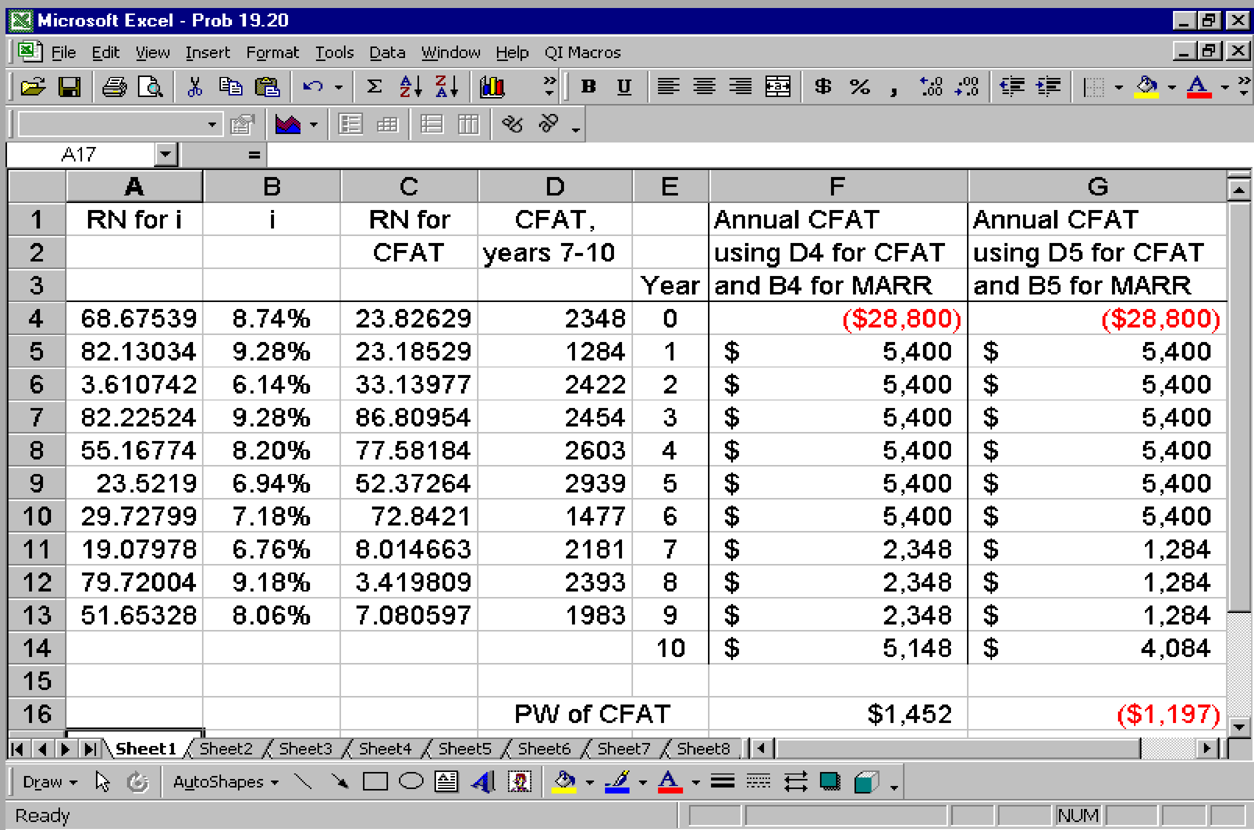
=NPV(\$B\$4,F5:F14)+F4

5. Columns F and G give two of the CFAT sequences, for example only, using rows 4 and 5 random number 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 spreadsheet NPV function. The value PW = \$-866 results from the i value in B4 (i = 9.88%) and PW = \$3680 results from applying the MARR in B5 (i = 6.02%).
6. Plot the PW values for as large a sample as desired. Or, following the logic of Figure 19-13, a spreadsheet relation can count the + and – PW values, with Xbar and s 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.

19.20 Use the spreadsheet Random Number Generator (RNG) on the tools toolbar to generate CFAT values in column D from a normal distribution with μ = \$2040 and σ = \$500. The RNG screen image is shown below. (This tool may not be available on all spreadsheets.)



19.20 (cont)



	A	B	C	D	E	F	G
1	RN for i	i	RN for	CFAT,		Annual CFAT	Annual CFAT
2			CFAT	years 7-10		using D4 for CFAT	using D5 for CFAT
3					Year	and B4 for MARR	and B5 for MARR
4	68.67539	8.74%	23.82629	2348	0	($28,800)	($28,800)
5	82.13034	9.28%	23.18529	1284	1	$ 5,400	$ 5,400
6	3.610742	6.14%	33.13977	2422	2	$ 5,400	$ 5,400
7	82.22524	9.28%	86.80954	2454	3	$ 5,400	$ 5,400
8	55.16774	8.20%	77.58184	2603	4	$ 5,400	$ 5,400
9	23.5219	6.94%	52.37264	2939	5	$ 5,400	$ 5,400
10	29.72799	7.18%	72.8421	1477	6	$ 5,400	$ 5,400
11	19.07978	6.76%	8.014663	2181	7	$ 2,348	$ 1,284
12	79.72004	9.18%	3.419809	2393	8	$ 2,348	$ 1,284
13	51.65328	8.06%	7.080597	1983	9	$ 2,348	$ 1,284
14					10	$ 5,148	$ 4,084
15							
16				PW of CFAT		$1,452	($1,197)

The spreadsheet above is the same as that in Problem 19.19, 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 19.19.

Extended Exercise Solution

This simulation is left to the student and the instructor. The same 7-step procedure from Section 19.5 applied in Problems 19.19 and 19.20 is used to set up the RNG for the cash flow values AOC and S, and the alternative life n for each alternative. The distributions given in the statement of the exercise are defined using the RNG.

For each of the 50-sample cash flow series, calculate the AW value for each alternative. To obtain a final answer of which alternative is the best to accept, 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.