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.

$$PW_8 = -10{,}000 + 2000(P/F,18\%,8) + (6500 - 4000)(P/A,18\%,8)$$
$$= -10{,}000 + 2000(0.2660) + 2500(4.0776)$$
$$= \$726$$

$$PW_{10} = -14{,}000 + 2500(P/F,18\%,8) + (10{,}000 - 5500)(P/A,18\%,8)$$
$$= \$5014$$

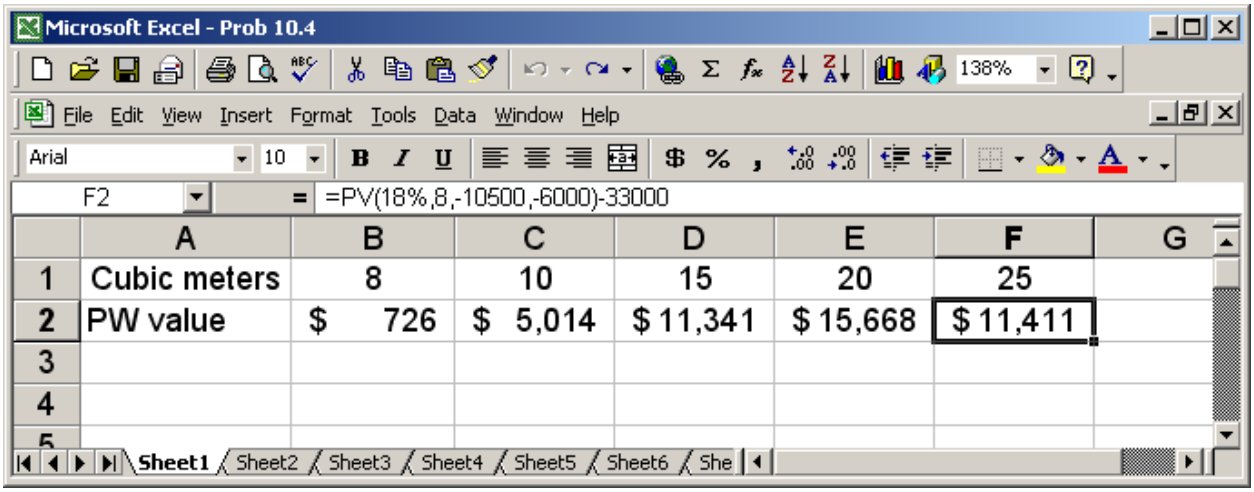
$$PW_{15} = -18{,}000 + 3000(P/F,18\%,8) + (14{,}000 - 7000)(P/A,18\%,8)$$
$$= \$11{,}341$$

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	G
1	Cubic meters	8	10	15	20	25	
2	PW value	$ 726	$ 5,014	$ 11,341	$ 15,668	$ 11,411	
3							
4							
5							

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(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.

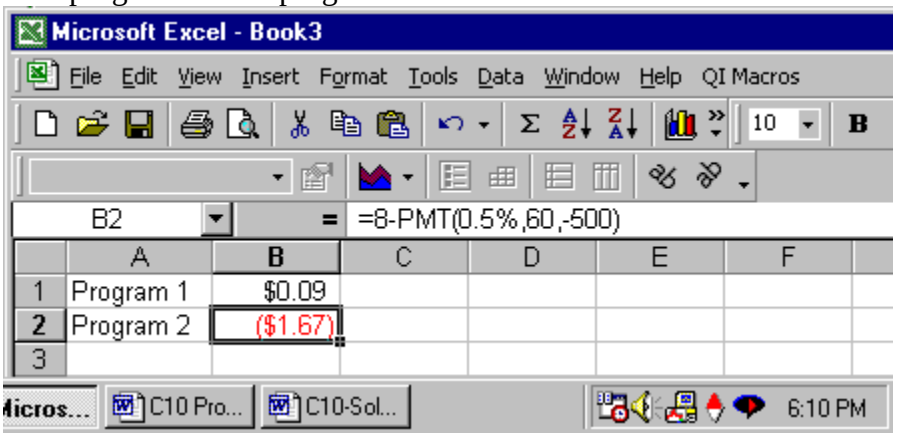
(b) The B/C method was the evaluation method in chapter 9, so rework it using AW.
Hand solution: Find the AW for each cash flow series on a per household per month basis.

$AW_1 = 1.25 – 60(A/P,0.5\%,60)$
$= 1.25 – 60(0.01933)$
$= 1.25 - 1.16$
$= \$0.09$

$AW_2 = 8.00 - 500(A/P,0.5\%,60)$
$= 8.00 – 9.67$
$= \$-1.67$

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.

$$T_e = 0.06 + (0.94)(0.20) = 0.248$$

After-tax MARR = 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%

10.14 (cont)

(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%.

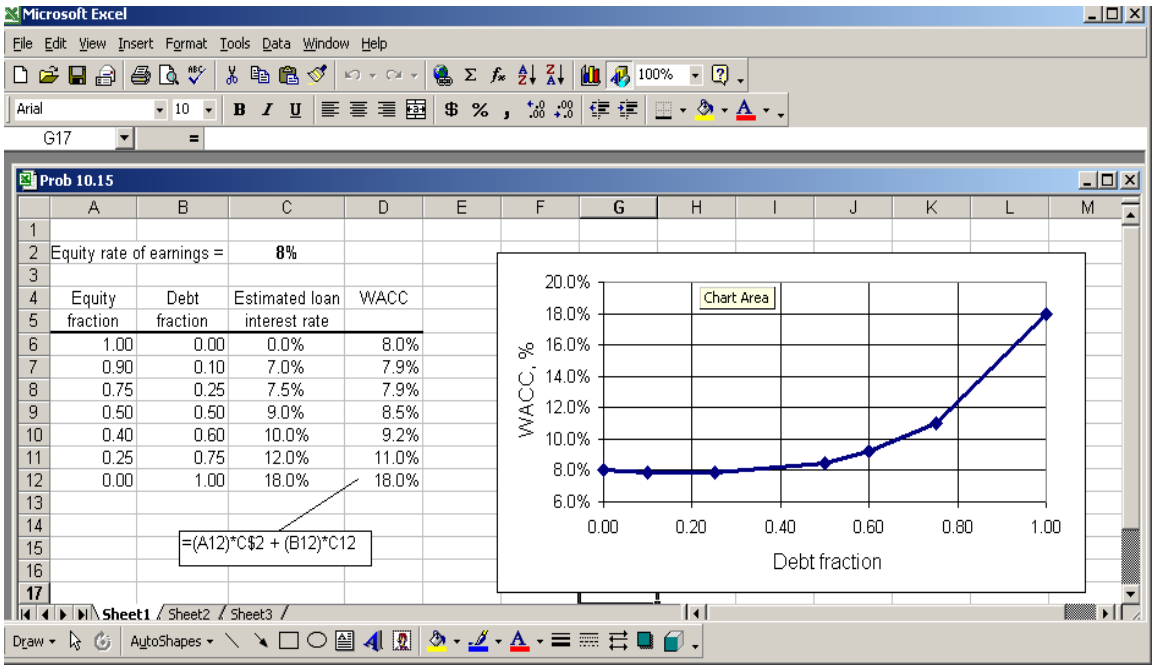
Alternative 2: $10\% = WACC_2 = 0.2(12\%) + 0.8(x_2)$

$x_2 = [10\% - 0.2(12\%)]/0.8$

$= 9.5\%$

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.



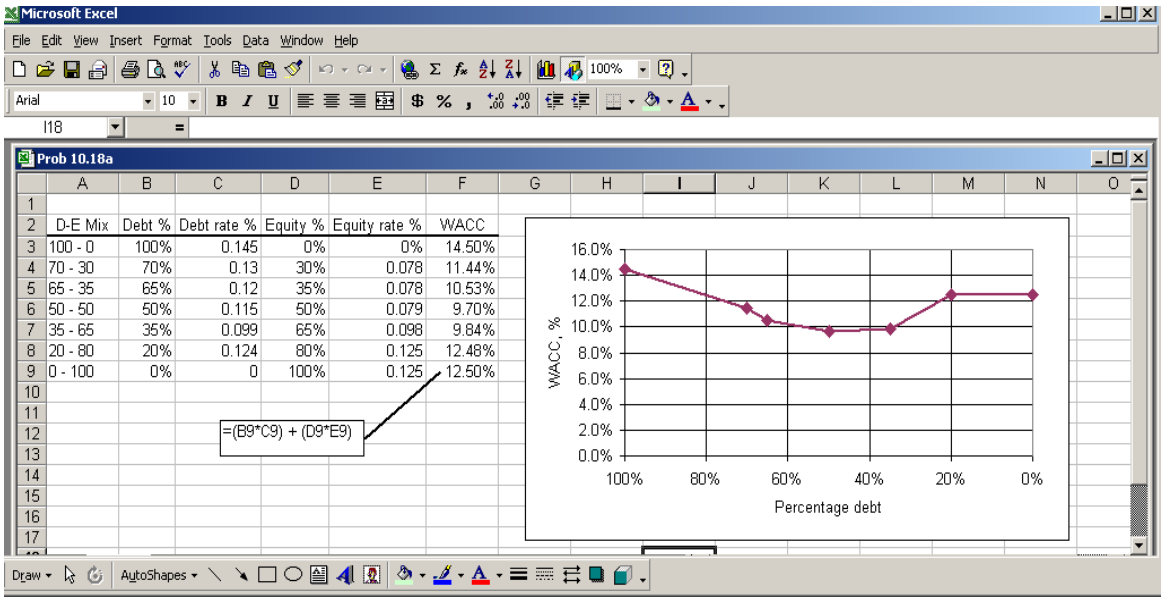
10.16 WACC = cost of debt capital + cost of equity capital
= (0.4)[0.667(8%) + 0.333(10%)] + (0.6)[(0.4)(5%) + (0.6)(9%)]
= 0.4[8.667%] + 0.6 [7.4%]
= 7.907%

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

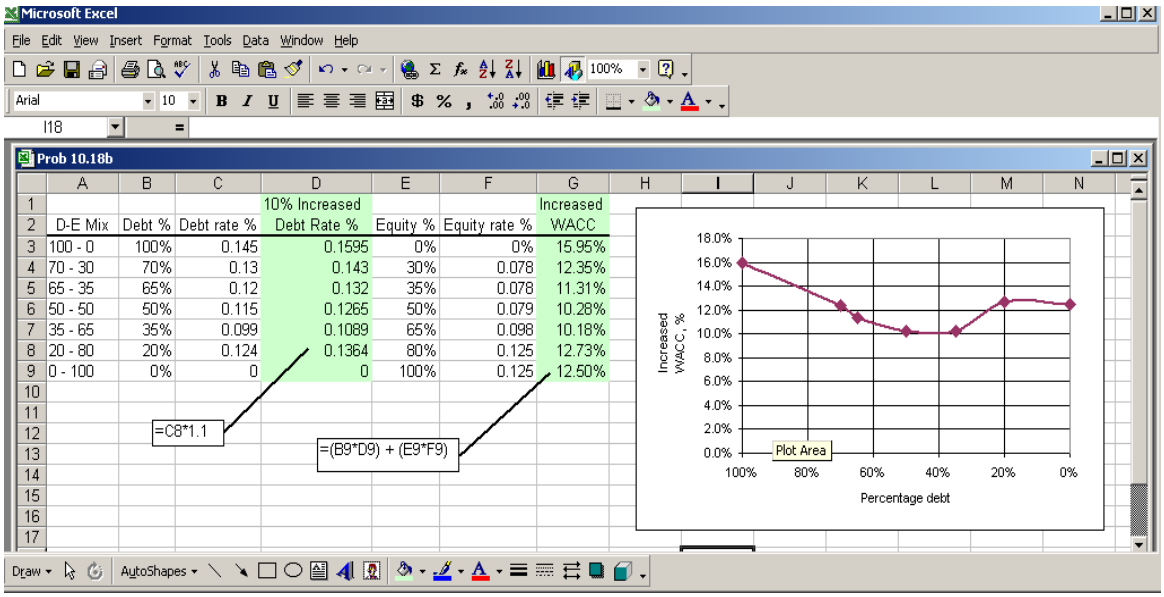
(b) D-E mix of 50%-50% has the lowest WACC value.

10.18 (a) The spreadsheet shows a 50% - 50% mix to have the lowest WACC at 9.70%.



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

(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%.



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

10.19 Solve for the cost of debt capital, x.

$$\text{WACC} = 10.7\% = 0.8(6\%) + (1-0.8)\,(x)$$
$$x = (10.7 - 4.8)/0.2$$
$$= 29.5\%$$

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.

$$\text{After-tax WACC} = (\text{equity})(\text{equity rate}) + (\text{debt})(\text{before-tax debt rate})(1 - T_e)$$
$$= 0.4(9\%) + 0.6(12\%)(1-0.35)$$
$$= 8.28\% \text{ per year}$$

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.

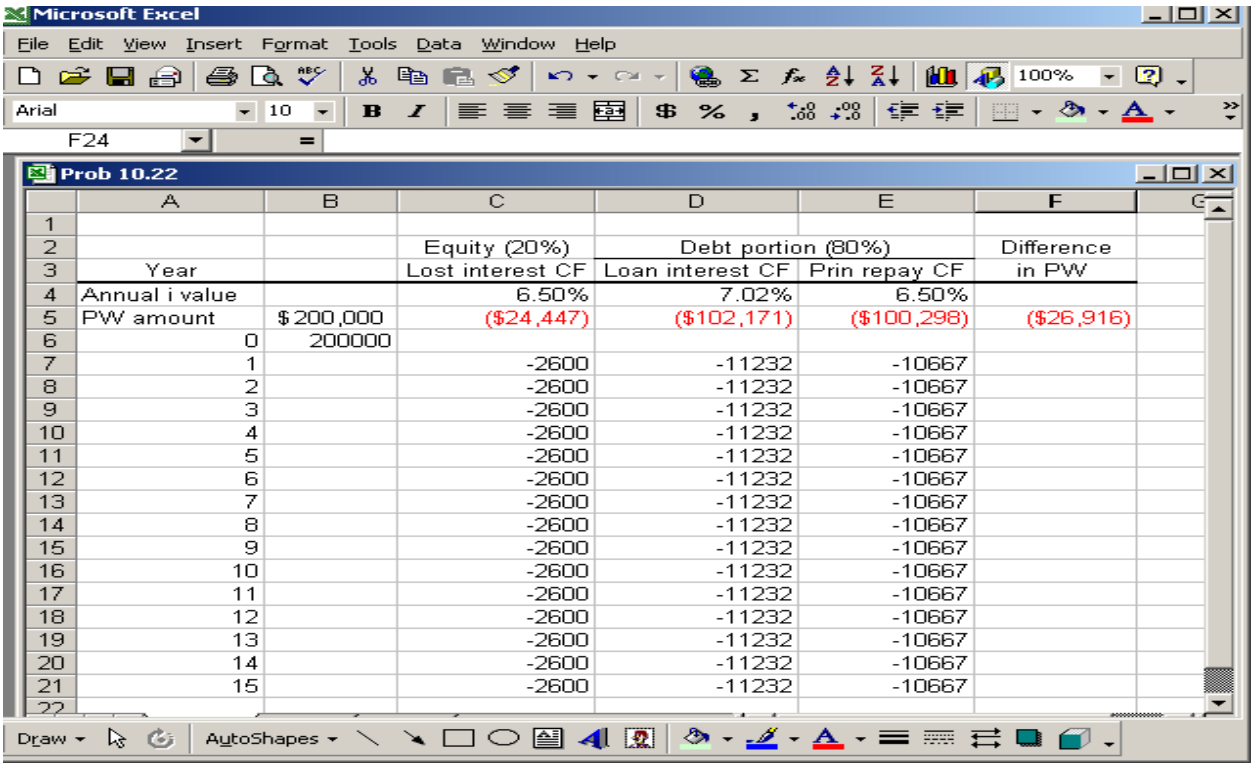
10.22 (cont)

Debt cost of capital: before-tax $(1\text{-}T_e) = 9\%(1\text{-}0.22) = 7.02\%$
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	
22						

(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.

WACC = 0.6(9.5%) + 0.32(5.44%) + 0.08(5.44%)
= 7.88%

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%

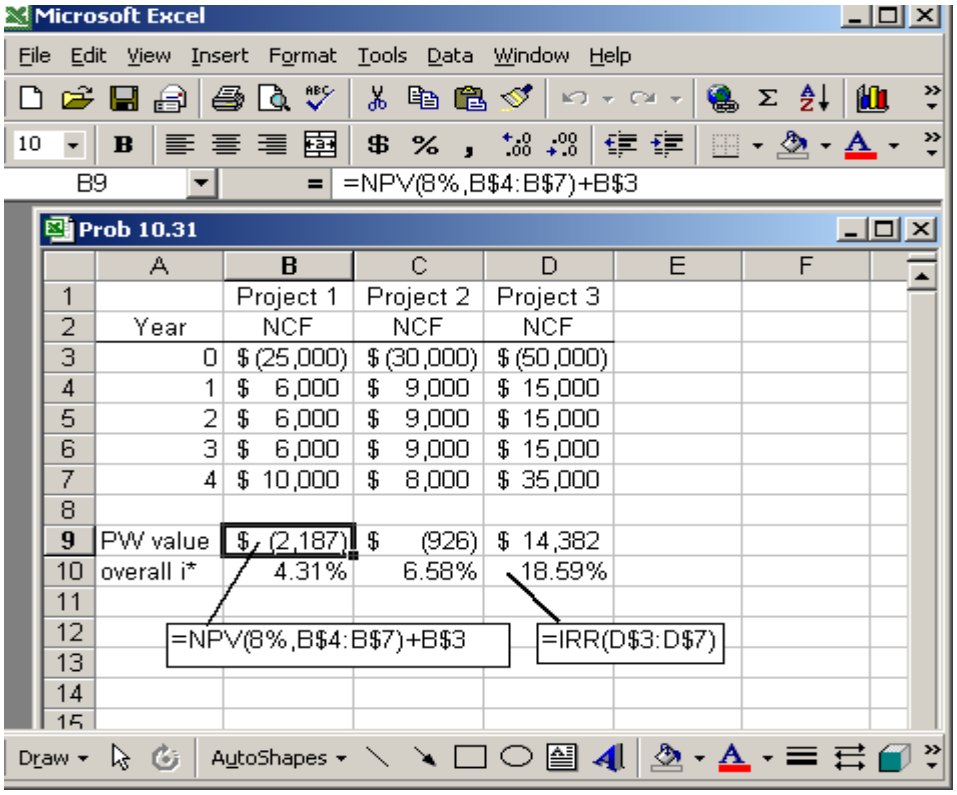
10.31 For the D-E mix of 70%-30%, WACC = 0.7(7.0%) + 0.3(10.34%) = 8.0%

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*



	A	B	C	D	E	F
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%		
11						
12						
13						
14						
15						

Independent: Only project 3 has PW > 0. Select it.

(b) Mutually exclusive: Since only $PW_3 > 0$, select it.

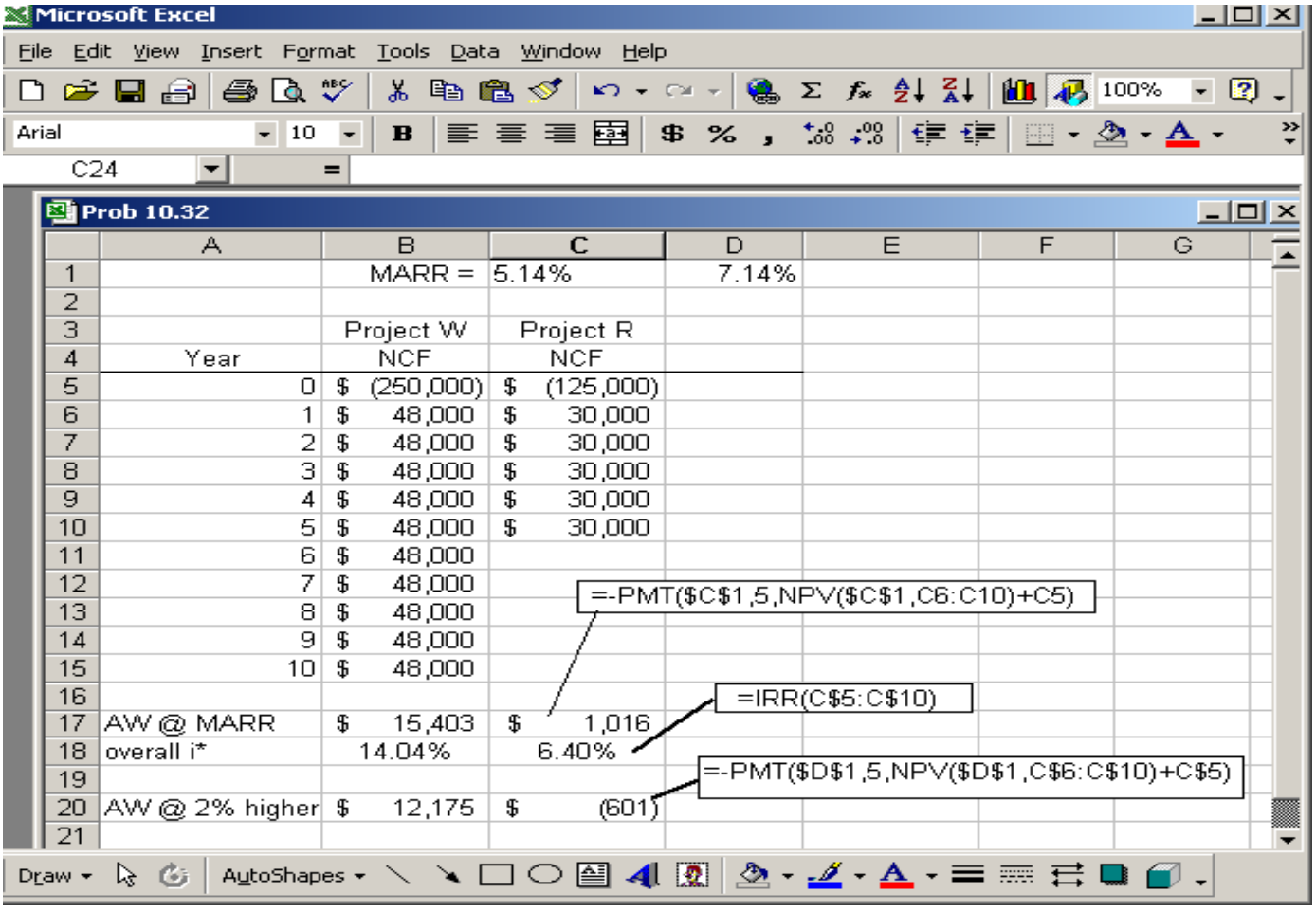
10.32 Two independent, revenue projects with different lives. Fastest solution is to find AW at MARR for each project. Select all those with AW > 0. Find WACC first.

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

$$\text{After-tax debt } i^* = [(1 + 0.05/4)^{4} - 1] (1- 0.3)$$
$$= 5.095(0.7) = 3.5665\% \text{ per year}$$

$$\text{WACC} = 0.4(7.5\%) + 0.6(3.5665\%) = 5.14\% \text{ per year}$$

$$\text{MARR} = \text{WACC} = 5.14\%$$



	A	B	C	D	E	F	G
1		MARR =	5.14%	7.14%			
2							
3		Project W	Project R				
4	Year	NCF	NCF				
5	0	$ (250,000)	$ (125,000)				
6	1	$ 48,000	$ 30,000				
7	2	$ 48,000	$ 30,000				
8	3	$ 48,000	$ 30,000				
9	4	$ 48,000	$ 30,000				
10	5	$ 48,000	$ 30,000				
11	6	$ 48,000					
12	7	$ 48,000					
13	8	$ 48,000					
14	9	$ 48,000					
15	10	$ 48,000					
16							
17	AW @ MARR	$ 15,403	$ 1,016				
18	overall i*	14.04%	6.40%				
19							
20	AW @ 2% higher	$ 12,175	$ (601)				
21							

(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>

Loan principal = 250,000(0.60) = $150,000

$$\begin{aligned} \text{Loan payment} &= 150{,}000(A/P,9\%,15) \\ &= 150{,}000(0.12406) \\ &= \$18{,}609 \text{ per year} \end{aligned}$$

Cost of 60% debt capital is 9% for the loan.

WACC = 0.4(8.5%) + 0.6(9%) = 8.8%

MARR = 8.8%

Annual NCF = project NCF - loan payment

= $30,000 – 18,609 = $11,391

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

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

PW = -100,000 + 11,391(P/A,8.8%,15)
= -100,000 + 11,391(8.1567)
= $ -7,087

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% (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.

	Committee member							
Attribute	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.

	Committee member							
Attribute	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 = (committed equity capital)(A/P,i_A*,n) + S(A/F, i_A*,n) + 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*

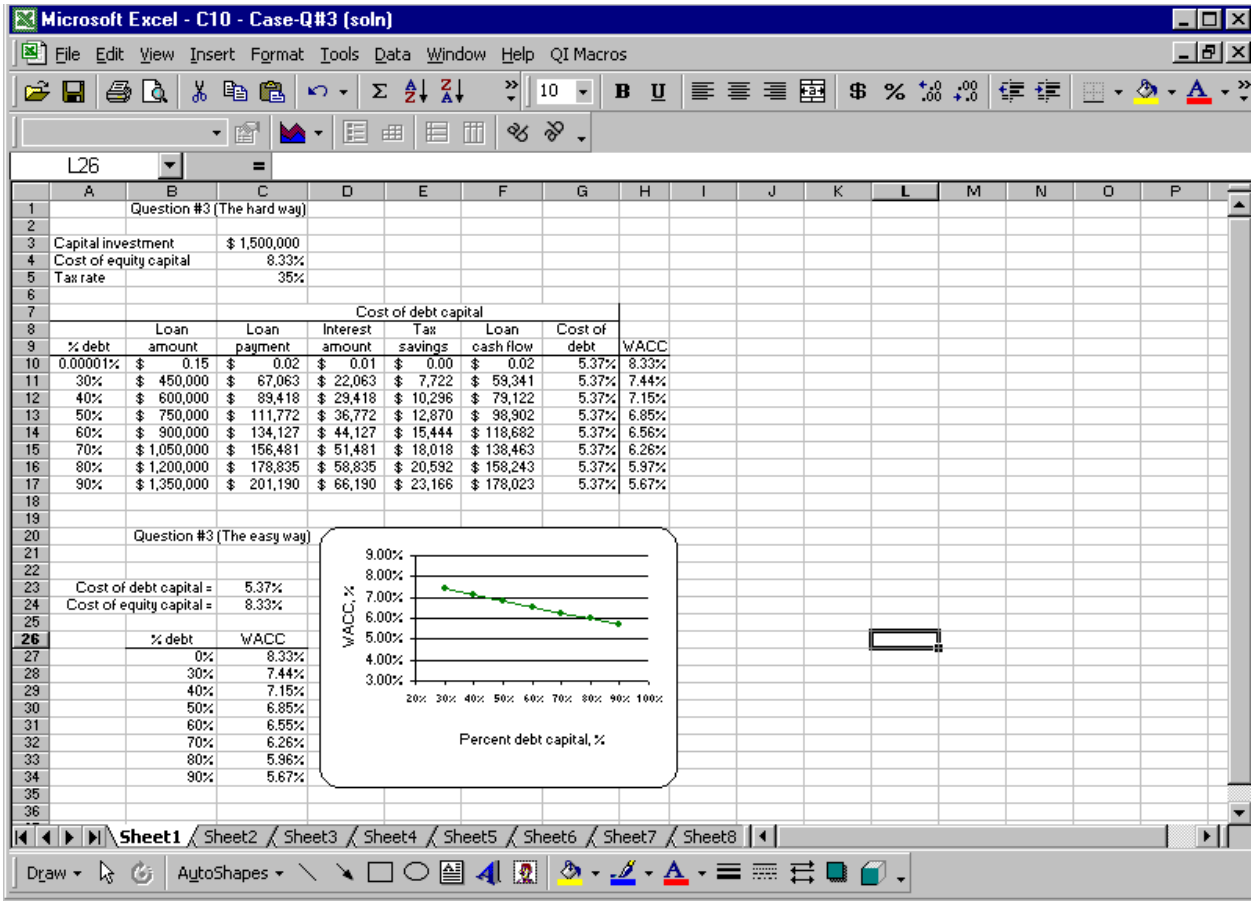
0 = -1,500,000(A/P,i_B*,10) + 200,000(A/F,i_B*,10) + 195,000

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)

	A	B	C	D	E	F	G	H
1		Question #3 (The hard way)						
2								
3	Capital investment		$ 1,500,000					
4	Cost of equity capital		8.33%					
5	Tax rate		35%					
6								
7				Cost of debt capital				
8		Loan	Loan	Interest	Tax	Loan	Cost of	
9	% debt	amount	payment	amount	savings	cash flow	debt	WACC
10	0.00001%	$ 0.15	$ 0.02	$ 0.01	$ 0.00	$ 0.02	5.37%	8.33%
11	30%	$ 450,000	$ 67,063	$ 22,063	$ 7,722	$ 59,341	5.37%	7.44%
12	40%	$ 600,000	$ 89,418	$ 29,418	$ 10,296	$ 79,122	5.37%	7.15%
13	50%	$ 750,000	$ 111,772	$ 36,772	$ 12,870	$ 98,902	5.37%	6.85%
14	60%	$ 900,000	$ 134,127	$ 44,127	$ 15,444	$ 118,682	5.37%	6.56%
15	70%	$ 1,050,000	$ 156,481	$ 51,481	$ 18,018	$ 138,463	5.37%	6.26%
16	80%	$ 1,200,000	$ 178,835	$ 58,835	$ 20,592	$ 158,243	5.37%	5.97%
17	90%	$ 1,350,000	$ 201,190	$ 66,190	$ 23,166	$ 178,023	5.37%	5.67%
18								
19								
20		Question #3 (The easy way)						
21								
22								
23	Cost of debt capital =		5.37%					
24	Cost of equity capital =		8.33%					
25								
26		% debt	WACC					
27		0%	8.33%					
28		30%	7.44%					
29		40%	7.15%					
30		50%	6.85%					
31		60%	6.55%					
32		70%	6.26%					
33		80%	5.96%					
34		90%	5.67%					
35								
36								

Sheet1 Sheet2 Sheet3 Sheet4 Sheet5 Sheet6 Sheet7 Sheet8