Chapter 5

Present Worth Analysis

Systematic Economic Analysis Technique

1. Identify the investment alternatives
2. Define the planning horizon
3. Specify the discount rate
4. Estimate the cash flows
5. Compare the alternatives
6. Perform supplementary analyses
7. Select the preferred investment

Measures of Economic Worth

- Present Worth ($\geq$ \$0)
- Future Worth ($\geq$ \$0)
- Annual Worth ($\geq$ \$0)
- Capitalized Worth ($\geq$ \$0)
- Discounted Payback Period ($\leq$ Value, e.g. 2 yrs)
- Payback Period ($\leq$ Value)
- Internal Rate of Return ($\geq$ MARR)
- External Rate of Return ($\geq$ MARR)
- Modified Internal Rate of Return ($\geq$ MARR)
- Benefit/Cost Ratio ($\geq$ 1.0)

Measures of Economic Worth

- **Ranking Methods**
  - Present Worth
  - Future Worth
  - Annual Worth
  - Capitalized Worth (represents PW for Infinite planning Horizon)
  - Discounted Payback Period (Time?)
  - Payback Period (Time?)
- **Incremental Methods**
  - Internal Rate of Return (%)
  - External Rate of Return (%)
  - Modified Internal Rate of Return (%)
  - Benefit/Cost Ratio

Measures of Economic Worth

- The following are consistent measures of economic worth, i.e., yield the same recommendation (*if performed correctly*)
  - Present Worth
  - Future Worth
  - Annual Worth
  - Internal Rate of Return
  - External Rate of Return
  - Benefit/Cost Ratio
- Capitalized worth yields the same recommendation if the planning horizon is ***infinitely long*** or equal to ***a least common multiple of lives*** of the investment alternatives

Present Worth Analysis

Single Alternative

Present Worth Method

- converts all cash flows to a single sum equivalent at time zero using *i* = *MARR* over the planning horizon
- the most popular DCF method

$$PW(i\%) = \sum_{i=0}^{n} A_t (1+i)^{-t}$$

(bring all cash flows back to "time zero" and add them up!)

Example 5.2

A $500,000 investment in a surface mount placement machine is being considered. Over a 10-year planning horizon, it is estimated the SMP machine will produce net annual savings of $92,500. At the end of 10 years, it is estimated the SMP machine will have a $50,000 salvage value. Based on a 10% MARR and a present worth analysis, should the investment be made?

PW = -$500K + $92.5K(P|A 10%,10) + $50K(P|F 10%,10)

= $87,650.50

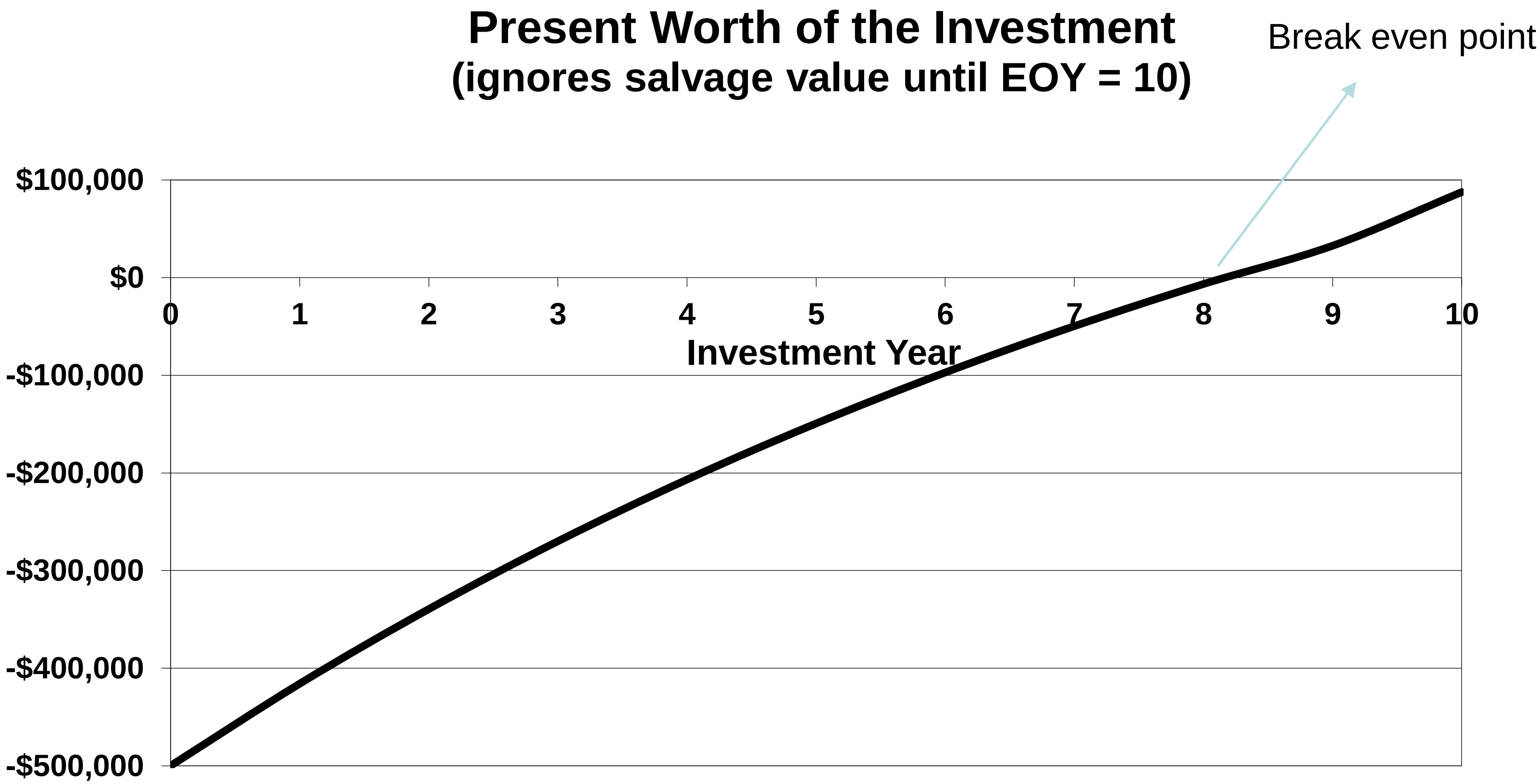
=PV(10%,10,-92500,-50000)-500000

= $87,649.62

Solving with Excel®,

MARR =	10%	(ignores salvage value until EOY = 10)	
EOY	CF	Cum(PW)	
0	-$500,000	-$500,000.00	=B3
1	$92,500	-$415,909.09	=NPV($B$1,$B$4:B4)+$B$3
2	$92,500	-$339,462.81	=NPV($B$1,$B$4:B5)+$B$3
3	$92,500	-$269,966.19	=NPV($B$1,$B$4:B6)+$B$3
4	$92,500	-$206,787.45	=NPV($B$1,$B$4:B7)+$B$3
5	$92,500	-$149,352.22	=NPV($B$1,$B$4:B8)+$B$3
6	$92,500	-$97,138.39	=NPV($B$1,$B$4:B9)+$B$3
7	$92,500	-$49,671.26	=NPV($B$1,$B$4:B10)+$B$3
8	$92,500	-$6,519.33	=NPV($B$1,$B$4:B11)+$B$3
9	$92,500	$32,709.70	=NPV($B$1,$B$4:B12)+$B$3
10	$142,500	$87,649.62	=NPV($B$1,$B$4:B13)+$B$3
PW =	$87,649.62	=NPV(B1,B4:B13)+B3	

Plotting Cumulative Present Worth,



Present Worth Analysis

Multiple Alternatives

$$\underset{\forall j}{Maximize}\ PW_j(i\%) = \sum_{i=0}^{n} A_{jt}(1+i)^{-t}$$

Choose the alternative with the greatest present worth

Example 5.3

Two design alternatives (A & B) are being considered for a new ride (The Scream Machine) at a theme park in Florida. Alternative A requires a $300,000 investment and will produce net annual revenue of $55,000/yr. Alternative B requires a $450,000 investment and will produce net annual revenue of $80,000/yr. At the end of the 10-yr planning horizon, both designs will have negligible salvage values. Based on a 10% *MARR*, which should be chosen? (The “do nothing” alternative is feasible and assumed to have a PW of $0.)

PW_A(10%) = -$300,000 + $55,000(*P*|*A* 10%,10) = $37,951.35

=PV(10%,10,-55000)-300000 = $37,951.19 > $0

(A is better than doing nothing)

PW_B(10%) = -$450,000 + $80,000(*P*|*A* 10%,10) = $41,565.60

=PV(10%,10,-80000)-450000 = $41,565.37 >$PW_A$

(B is better than A)

Example 5.3

Two design alternatives (A & B) are being considered for a new ride (The Scream Machine) at a theme park in Florida. Alternative A requires a $300,000 investment and will produce net annual revenue of $55,000/yr. Alternative B requires a $450,000 investment and will produce net annual revenue of $80,000/yr. At the end of the 10-yr planning horizon, both designs will have negligible salvage values. Based on a 10% *MARR*, which should be chosen? (The “do nothing” alternative is feasible and assumed to have a PW of $0.)

How does PW change with changing *MARR*?

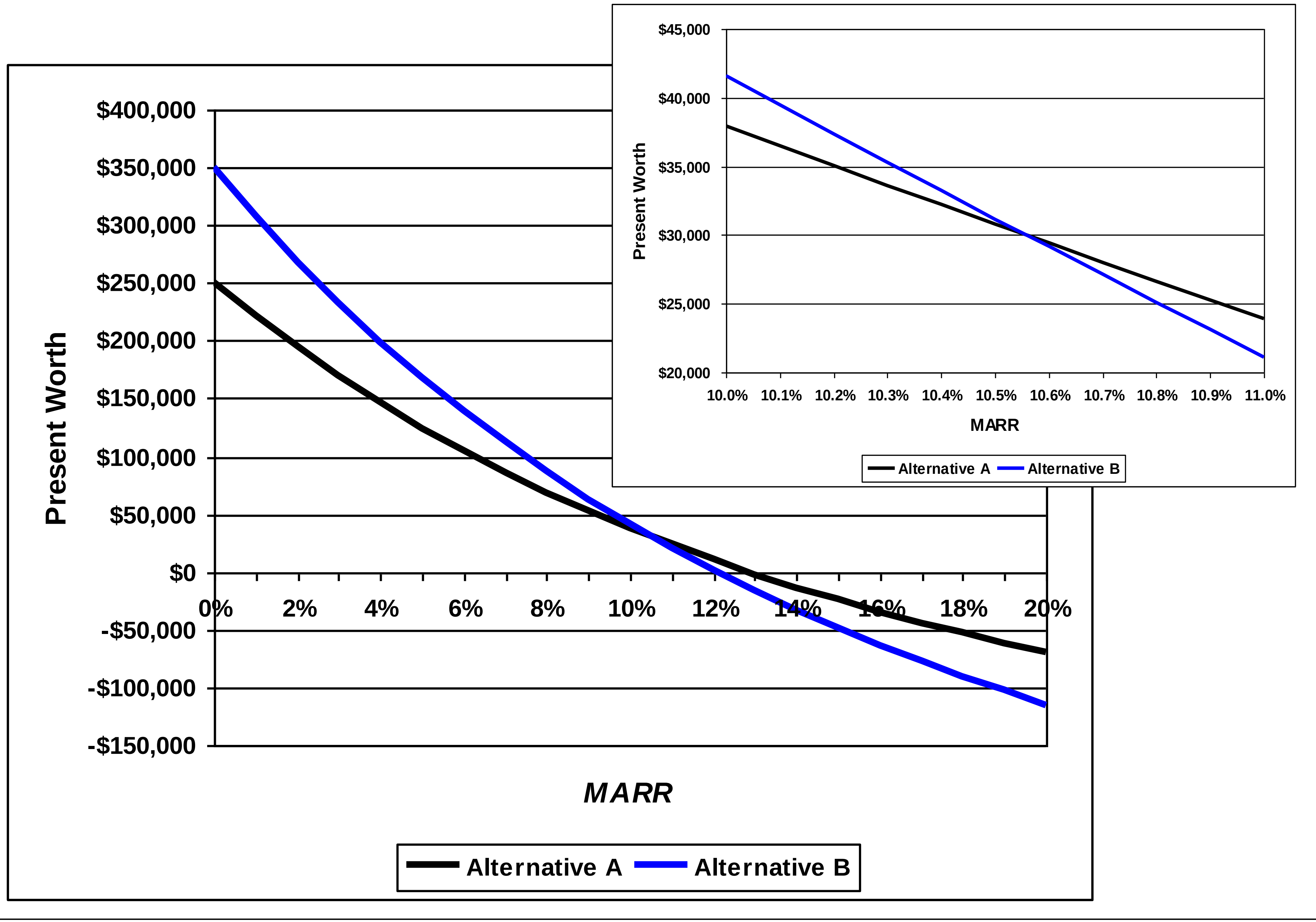
=PV(10%,10,-55000)-300000 = $37,951.19 > $0

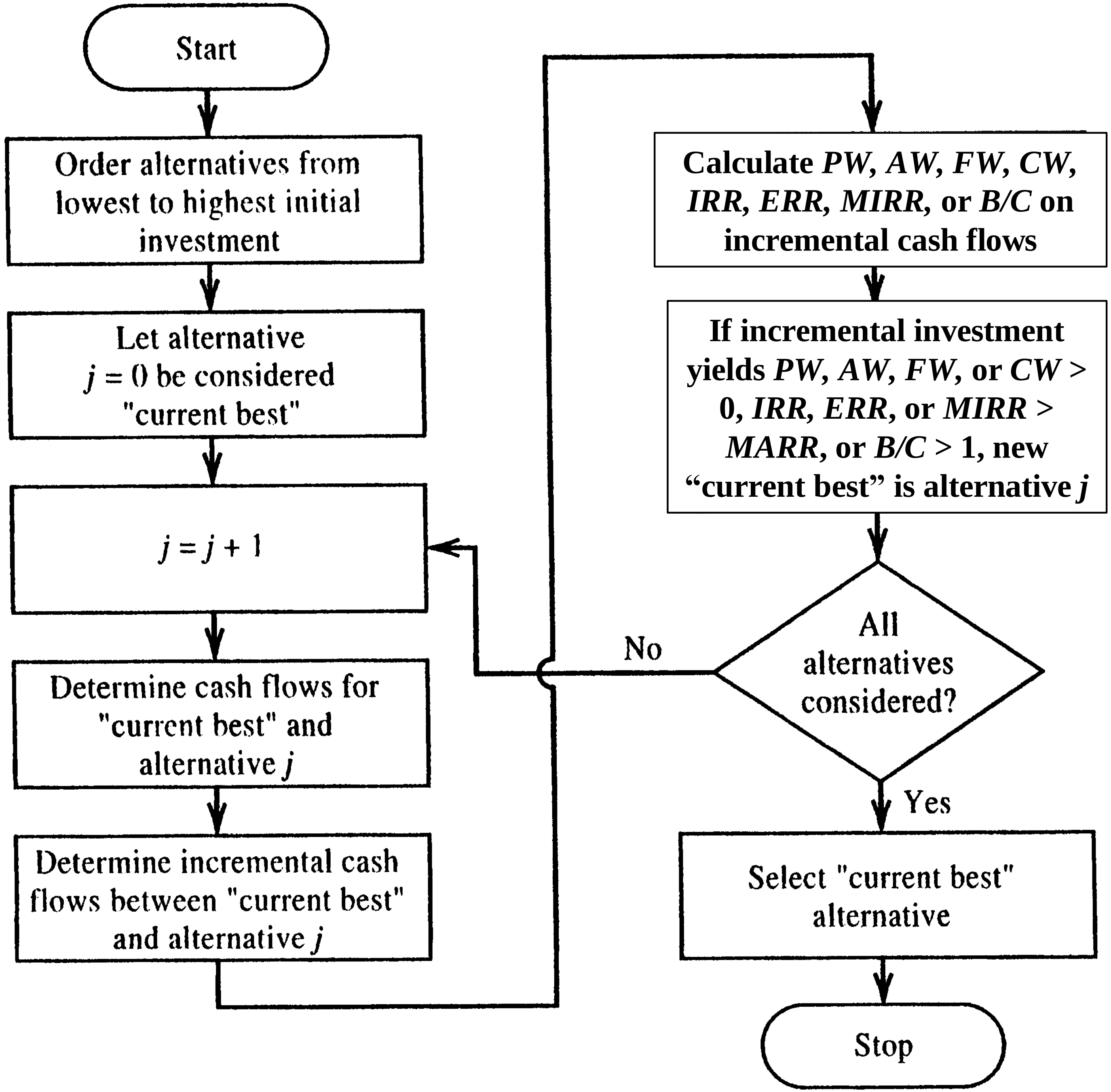
(A is better than doing nothing)

$PW_B(10\%)$ = -$450,000 + $80,000(*P*|*A* 10%,10) = $41,565.60

=PV(10%,10,-80000)-450000 = $41,565.37 $>PW_A$

(B is better than A)


$45,000
$40,000
$35,000
$30,000
$25,000
$20,000
Present Worth
10.0%
10.1%
10.2%
10.3%
10.4%
10.5%
10.6%
10.7%
10.8%
10.9%
11.0%
MARR
Alternative A
Alternative B
$400,000
$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
-$50,000
-$100,000
-$150,000
Present Worth
0%
2%
4%
6%
8%
10%
12%
14%
16%
18%
20%
MARR
Alternative A
Alternative B



Flow Chart for the Incremental Comparison of Investment Alternatives

Example 5.4

Let's use an incremental approach to evaluate the two design alternatives for a new ride at a theme park. Recall, Alternative A required a $300,000 investment and produced annual revenue of $55,000; Alternative B required a $450,000 investment and produced annual revenue of $80,000. At the end of the 10-yr planning horizon, both had negligible salvage values. Based on a 10% *MARR*, which should be chosen?

$PW_A(10\%) = -\$300{,}000 + \$55{,}000(P|A\ 10\%,10) = \$37{,}951.35$

=PV(10%,10,-55000)-300000 = $37,951.19 > $0

(A is better than doing nothing)

$PW_{B-A}(10\%) = -\$150{,}000 + \$25{,}000(P|A\ 10\%,10) = \$3{,}614.25$

=PV(10%,10,-25000)-150000 = $3,614.18 > $0

-450k- (-300k)

(B is better than A)

80 k-55k

Present Worth Analysis

"One Shot" Investments

Example 5.5

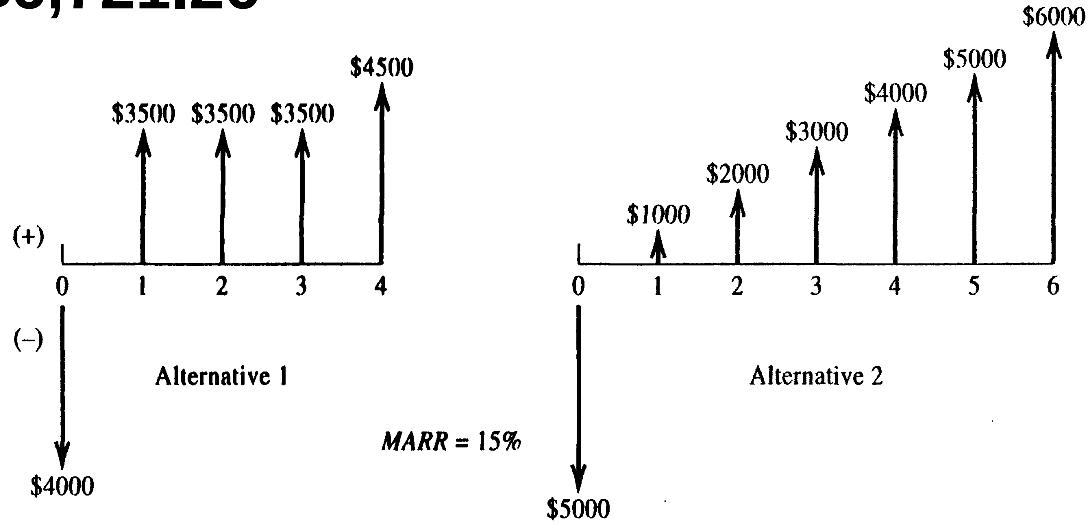
Two investment alternatives (1 & 2) are available, with the CFDs shown below. They are “one shot” investments. Using a 15% MARR, which should be chosen?

$$PW_1(15\%) = -\$4,000 + \$3,500(P|A\ 15\%,4) + \$1,000(P|F\ 15\%,4)$$

$$PW_1(15\%) = \$6,564.18$$

$$PW_2(15\%) = -\$5,000 + \$1,000(P|A\ 15\%,6) + \$1,000(P|G\ 15\%,6)$$

$$PW_2(15\%) = \$6,721.26$$



Example 5.5

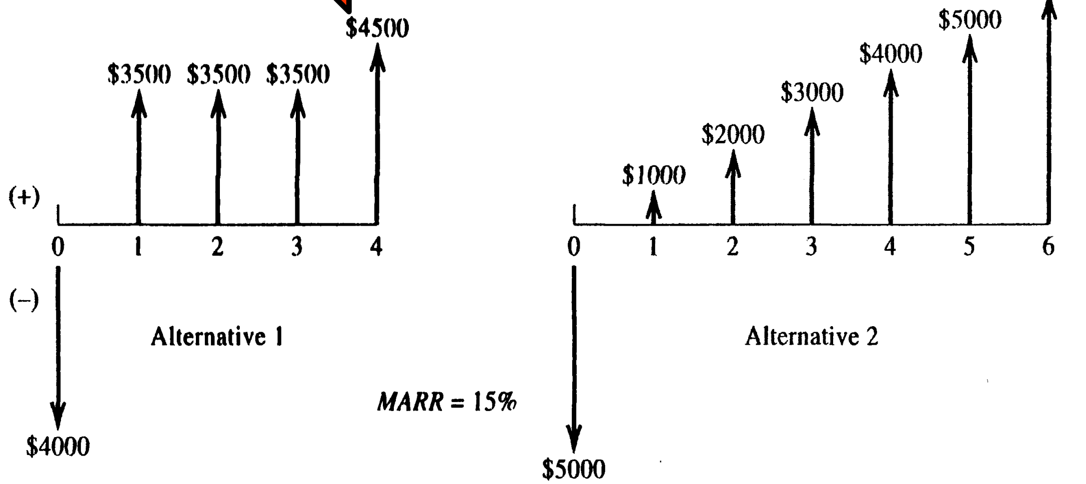
Two investment alternatives (1 & 2) are available, with the CFDs shown below. They are "one shot" investments. Using a 15% MARR, which should be chosen?

$$PW_1(15\%) = -\$4,000 + \$3,500(P|A\ 15\%,4) + \$1,000(P|F\ 15\%,4)$$

$$PW_1(15\%) = \$6,564.18$$

$$PW_2(15\%) = -\$5,000 + \$1,000(P|A\ 15\%,6) + \$1,000(P|G\ 15\%,6)$$

$$PW_2(15\%) = \$6,721.26$$



Discounted Payback Period Analysis (does not consider values after break even point but PW does)

Single Alternative

Discounted Payback Period (DPP) Method

- determines how long it takes to fully recover an investment while considering the time value of money (MARR)
- increasing in popularity
- determine the smallest value of *m* such that

$$\sum_{t=0}^{m} A_t (1+i)^{-t} \geq 0$$

(determine the point in time when cumulative discounted cash flow $\geq$ \$0)

Discounted Payback Period

- EASTMAN calls this the *net present value payback year*
- Let's use Excel's® SOLVER and/or GOAL SEEK to determine the DPBP for the SMP investment with salvage value decreasing as geometric and gradient series.

Example 5.6

Based on a 10% MARR, how long does it take for the $500,000 investment in a surface mount placement machine to be recovered, based on an annual savings of $92,500 and a negligible salvage value, regardless of how long the machine is used? (either by trial and error or by using equation ch 2)

 # years =NPER(10%,92500,-500000)

= 8.16 years

PW=0

-500 K+92,500 (P/A 10,n)=0

Solving with Excel®,

MARR =	10%	(ignores salvage value until EOY = 10)	
EOY	CF	Cum(PW)	
0	-$500,000	-$500,000.00	=B3
1	$92,500	-$415,909.09	=NPV($B$1,$B$4:B4)+$B$3
2	$92,500	-$339,462.81	=NPV($B$1,$B$4:B5)+$B$3
3	$92,500	-$269,966.19	=NPV($B$1,$B$4:B6)+$B$3
4	$92,500	-$206,787.45	=NPV($B$1,$B$4:B7)+$B$3
5	$92,500	-$149,352.22	=NPV($B$1,$B$4:B8)+$B$3
6	$92,500	-$97,138.39	=NPV($B$1,$B$4:B9)+$B$3
7	$92,500	-$49,671.26	=NPV($B$1,$B$4:B10)+$B$3
8	$92,500	-$6,519.33	=NPV($B$1,$B$4:B11)+$B$3
9	$92,500	$32,709.70	=NPV($B$1,$B$4:B12)+$B$3
10	$142,500	$87,649.62	=NPV($B$1,$B$4:B13)+$B$3
PW =	$87,649.62	=NPV(B1,B4:B13)+B3	

Example 5.6 (Continued)

How is the PW of the investment in the SMP machine affected when salvage value decreases from $500,000 to $50,000 over the 10-year planning horizon? Consider both geometric and gradient decreases.

Example 5.6 (Continued)

How is the PW of the investment in the SMP machine affected when salvage value decreases from \$500,000 to \$50,000 over the 10-year planning horizon? Consider both geometric and gradient decreases.

G = (\$500,000 - \$50,000)/10 = \$45,000/yr

j =RATE(10,,-500000,50000) = -20.6%/yr

1	MARR =	10%					
2	EOY	CF	$SV_{geometric}$	$Cum(PW_{geom})$	$SV_{gradient}$	$Cum(PW_{grad})$	
3	0	-$500,000	$500,000	n/a	$500,000	n/a	
4	1	$92,500	$397,500	-$54,545.45	$455,000	-$2,272.73	=PV($B$1,A4,-B4,-E4)+$B$3
5	2	$92,500	$316,013	-$78,295.45	$410,000	-$619.83	=PV($B$1,A5,-B5,-E5)+$B$3
6	3	$92,500	$251,230	-$81,213.42	$365,000	$4,263.71	=PV($B$1,A6,-B6,-E6)+$B$3
7	4	$92,500	$199,728	-$70,370.67	$320,000	$11,776.86	=PV($B$1,A7,-B7,-E7)+$B$3
8	5	$92,500	$158,784	-$50,760.10	$275,000	$21,401.14	=PV($B$1,A8,-B8,-E8)+$B$3
9	6	$92,500	$126,233	-$25,883.17	$230,000	$32,690.62	=PV($B$1,A9,-B9,-E9)+$B$3
10	7	$92,500	$100,355	$1,826.83	$185,000	$45,262.99	=PV($B$1,A10,-B10,-E10)+$B$3
11	8	$92,500	$79,782	$30,699.75	$140,000	$58,791.71	=PV($B$1,A11,-B11,-E11)+$B$3
12	9	$92,500	$63,427	$59,608.94	$95,000	$72,998.98	=PV($B$1,A12,-B12,-E12)+$B$3
13	10	$92,500	$50,424	$87,813.27	$50,000	$87,649.62	=PV($B$1,A13,-B13,-E13)+$B$3

Cum $(PW_{geom})_{t=1}$ **= -\$500,000 + \$92,500(P|F 10%,1)+ \$397,500(P|F 10%,1)**
= -\$54,545.45

1	MARR =	10%					
2	EOY	CF	$SV_{geometric}$	$Cum(PW_{geom})$	$SV_{gradient}$	$Cum(PW_{grad})$	
3	0	-$500,000	$500,000	n/a	$500,000	n/a	
4	1	$92,500	$397,500	-$54,545.45	$455,000	-$2,272.73	=PV($B$1,A4,-B4,-E4)+$B$3
5	2	$92,500	$316,013	-$78,295.45	$410,000	-$619.83	=PV($B$1,A5,-B5,-E5)+$B$3
6	3	$92,500	$251,230	-$81,213.42	$365,000	$4,263.71	=PV($B$1,A6,-B6,-E6)+$B$3
7	4	$92,500	$199,728	-$70,370.67	$320,000	$11,776.86	=PV($B$1,A7,-B7,-E7)+$B$3
8	5	$92,500	$158,784	-$50,760.10	$275,000	$21,401.14	=PV($B$1,A8,-B8,-E8)+$B$3
9	6	$92,500	$126,233	-$25,883.17	$230,000	$32,690.62	=PV($B$1,A9,-B9,-E9)+$B$3
10	7	$92,500	$100,355	$1,826.83	$185,000	$45,262.99	=PV($B$1,A10,-B10,-E10)+$B$3
11	8	$92,500	$79,782	$30,699.75	$140,000	$58,791.71	=PV($B$1,A11,-B11,-E11)+$B$3
12	9	$92,500	$63,427	$59,608.94	$95,000	$72,998.98	=PV($B$1,A12,-B12,-E12)+$B$3
13	10	$92,500	$50,424	$87,813.27	$50,000	$87,649.62	=PV($B$1,A13,-B13,-E13)+$B$3

Cum $(PW_{geom})_{t=1}$ **= -\$500,000 + \$92,500(P|A 10%,3)+ \$251,230(P|F 10%,3)**
= -\$81213.55

Chapter 5 tables and figures (09-30-08) [Compatibility Mode] - Microsoft Excel

D13 =PV($B$1,A13,-B13,-C13)+$B$3

	A	B	C	D	E	F	G
1	MARR =	10%					
2	EOY	CF	$SV_{geometric}$	$Cum(PW_{geom})$	$SV_{gradient}$	$Cum(PW_{grad})$	
3	0	-$500,000	$500,000	n/a	$500,000	n/a	
4	1	$92,500	$397,500	-$54,545.45	$455,000	-$2,272.73	=PV($B$1,A4,-B4,-E4)+$B$3
5	2	$92,500	$316,013	-$78,295.45	$410,000	-$619.83	=PV($B$1,A5,-B5,-E5)+$B$3
6	3	$92,500	$251,230	-$81,213.42	$365,000	$4,263.71	=PV($B$1,A6,-B6,-E6)+$B$3
7	4	$92,500	$199,728	-$70,370.67	$320,000	$11,776.86	=PV($B$1,A7,-B7,-E7)+$B$3
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9	6	$92,500	$126,233	-$25,883.17	$230,000	$32,690.62	=PV($B$1,A9,-B9,-E9)+$B$3
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13	10	$92,500	$50,424	$87,813.27	$50,000	$87,649.62	=PV($B$1,A13,-B13,-E13)+$B$3

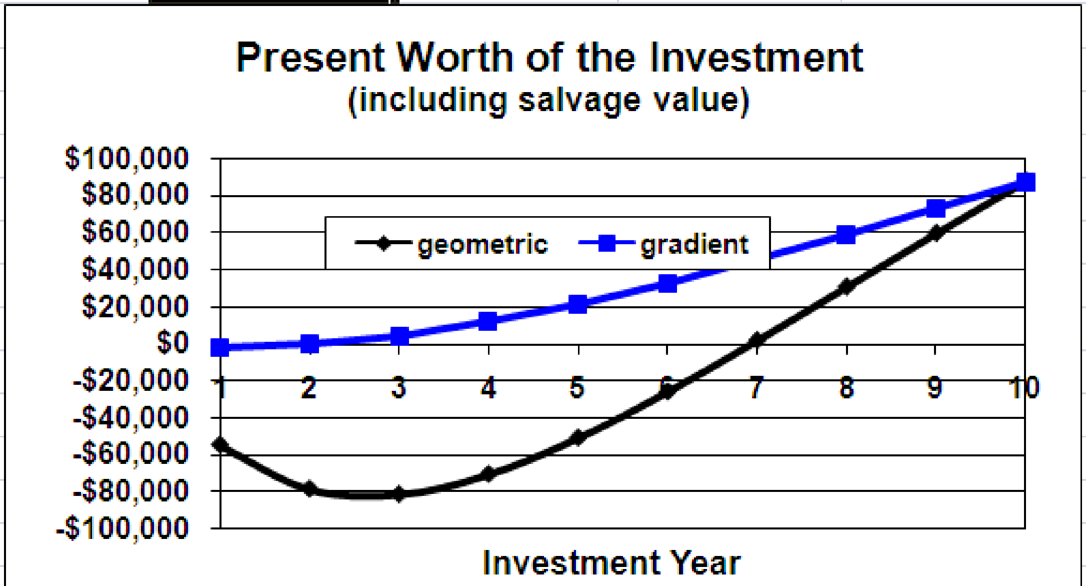


Figure 5.4 | Figure 5.5 | Figure 5.6 | Figure 5.7 | Figure 5.8 | Figure 5.9 | Figure 5.10

Example 5.7

Based on a 10% MARR, how long does it take for the $500,000 investment in a surface mount placement machine to be recovered, based on an annual savings of $92,500 and a salvage value at the end of n years equal to

a) $\$500,000(1 - 0.206)^n$ and

b) $500,000 - $45,000n?

The Excel® SOLVER tool is used to solve the example.

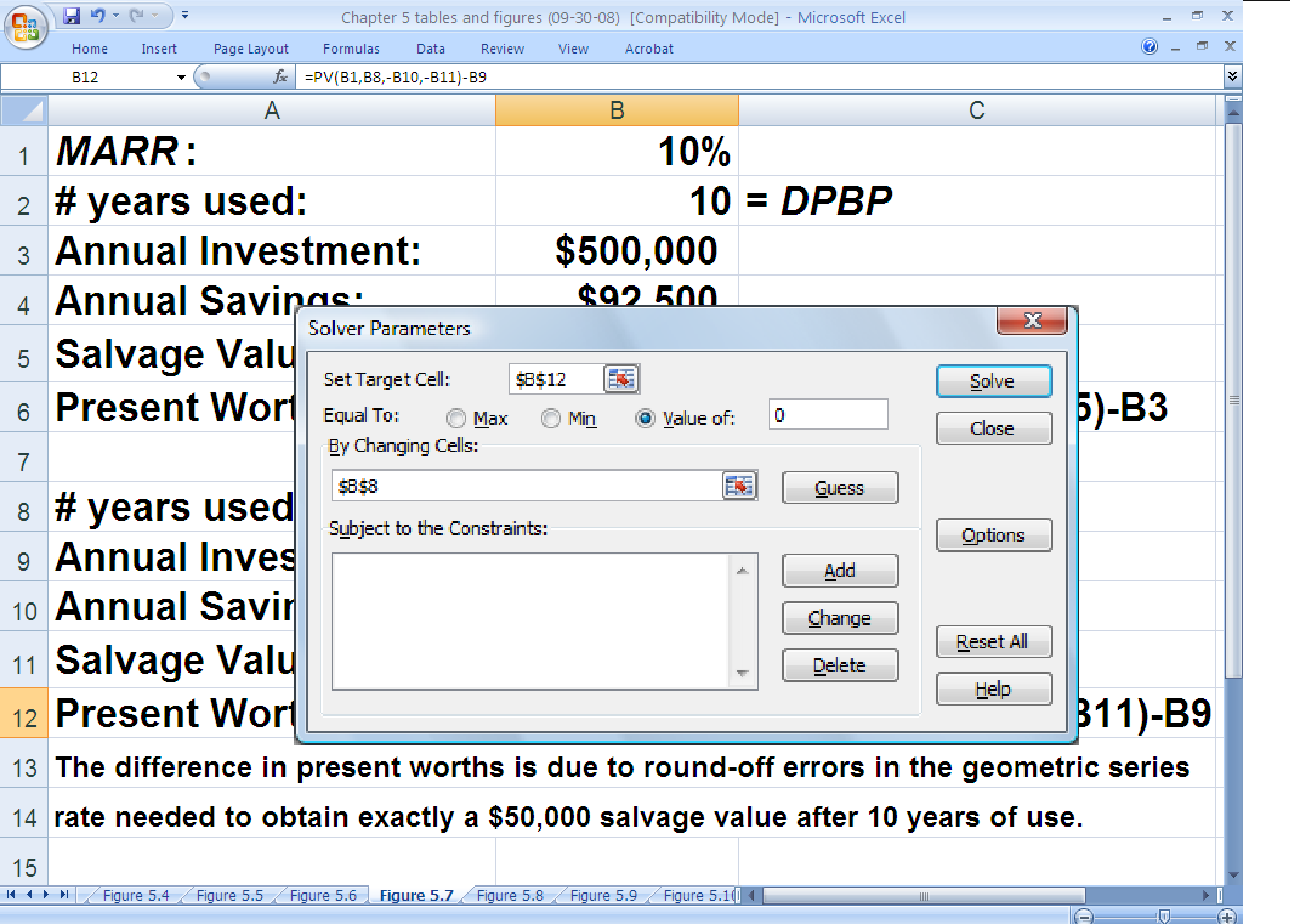
(**note: same example 5.6 except Salvage value should be considered**)

Chapter 5 tables and figures (09-30-08) [Compatibility Mode] - Microsoft Excel

B12 =PV(B1,B8,-B10,-B11)-B9

	A	B	C
1	***MARR*:**	**10%**	
2	**# years used:**	**10**	**= *DPBP***
3	**Annual Investment:**	**$500,000**	
4	**Annual Savings:**	**$92,500**	
5	**Salvage Value $_{geometric}$:**	**$49,794**	**=B3*(1-0.206)^B2**
6	**Present Worth:**	**$87,570.11**	**=PV(B1,B2,-B4,-B5)-B3**
7			
8	**# years used:**	**10**	**= *DPBP***
9	**Annual Investment:**	**$500,000**	
10	**Annual Savings:**	**$92,500**	
11	**Salvage Value $_{gradient}$:**	**$50,000**	**=B9-B8*45000**
12	**Present Worth:**	**$87,649.62**	**=PV(B1,B8,-B10,-B11)-B9**
13	**The difference in present worths is due to round-off errors in the geometric series**		
14	**rate needed to obtain exactly a $50,000 salvage value after 10 years of use.**		
15			

Figure 5.4 | Figure 5.5 | Figure 5.6 | **Figure 5.7** | Figure 5.8 | Figure 5.9 | Figure 5.1(



Chapter 5 tables and figures (09-30-08) [Compatibility Mode] - Microsoft Excel
Home Insert Page Layout Formulas Data Review View Acrobat
B12
=PV(B1,B8,-B10,-B11)-B9
MARR: 10%
years used: 10 = DPBP
Annual Investment: $500,000
Annual Savings: $92,500
Salvage Valu
Present Wort
5)-B3
years used
Annual Inves
Annual Savir
Salvage Valu
Present Wort
311)-B9
The difference in present worths is due to round-off errors in the geometric series
rate needed to obtain exactly a $50,000 salvage value after 10 years of use.
Solver Parameters
Set Target Cell: $B$12
Equal To: Max Min Value of: 0
By Changing Cells:
$B$8
Guess
Subject to the Constraints:
Add
Change
Delete
Solve
Close
Options
Reset All
Help
Figure 5.4 Figure 5.5 Figure 5.6 Figure 5.7 Figure 5.8 Figure 5.9 Figure 5.1

Chapter 5 tables and figures (11-13-08) [Compatibility Mode] - Microsoft Excel

B12 =PV(B1,B8,-B10,-B11)-B9

	A	B	C
1	***MARR*:**	**10%**	
2	**# years used:**	**6.95187521**	**= *DPBP***
3	**Annual Investment:**	**$500,000**	
4	**Annual Savings:**	**$92,500**	
5	**Salvage Value $_{geometric}$:**	**$100,585**	**=B3*(1-0.206)^B2**
6	**Present Worth:**	**$0.00**	**=PV(B1,B2,-B4,-B5)-B3**
7			
8	**# years used:**	**2.16997447**	**= *DPBP***
9	**Annual Investment:**	**$500,000**	
10	**Annual Savings:**	**$92,500**	
11	**Salvage Value $_{gradient}$:**	**$402,351**	**=B9-B8*45000**
12	**Present Worth:**	**$0.00**	**=PV(B1,B8,-B10,-B11)-B9**
13	**The difference in present worths is due to round-off errors in the geometric series**		
14	**rate needed to obtain exactly a $50,000 salvage value after 10 years of use.**		
15			

Figure 5.2 | Figure 5.3 | Figure 5.4 | Figure 5.5 | Figure 5.6 | **Figure 5.7** | Figure 5.8

Payback Period Method (PBP)

- EASTMAN calls it the *cash payback year*
- determines the length of time required to recover the initial investment without considering the time value of money (no interest been considered)
- not equivalent to those already considered
- a popular method of valuing investments
- determine the smallest value of m such that

$$\sum_{t=0}^{m} A_t \geq 0$$

(ignores cash flows that occur after the payback period)

Why Use the Payback Period Method?

- does not require interest rate calculations
- does not require a decision concerning the MARR
- easily explained and understood
- reflects a manager's attitudes when capital is limited
- hedge against uncertainty of future cash flows
- provides a rough measure of the liquidity of an investment

Example 5.8

What is the payback period for the $500,000 SMP investment, given an annual savings of $92,500?

PBP = $500,000/$92,500

= 5.4054 years

=NPER(0%,92500,-500000)

= 5.4054

Discounted Payback Period Analysis

Multiple Alternatives

Example 5.9

Now, suppose a third design (alternative C) is developed for The Scream Machine. As before, A requires a $300,000 investment and produces revenue of $55,000/yr; and B requires a $450,000 investment and produces revenue of $80,000/yr. The new design (C) requires a $150,000 investment and produces 1st year revenue of $45,000; thereafter, revenue decreases by $5000/yr. Based on a 10% *MARR*, which design has the smallest DPBP?

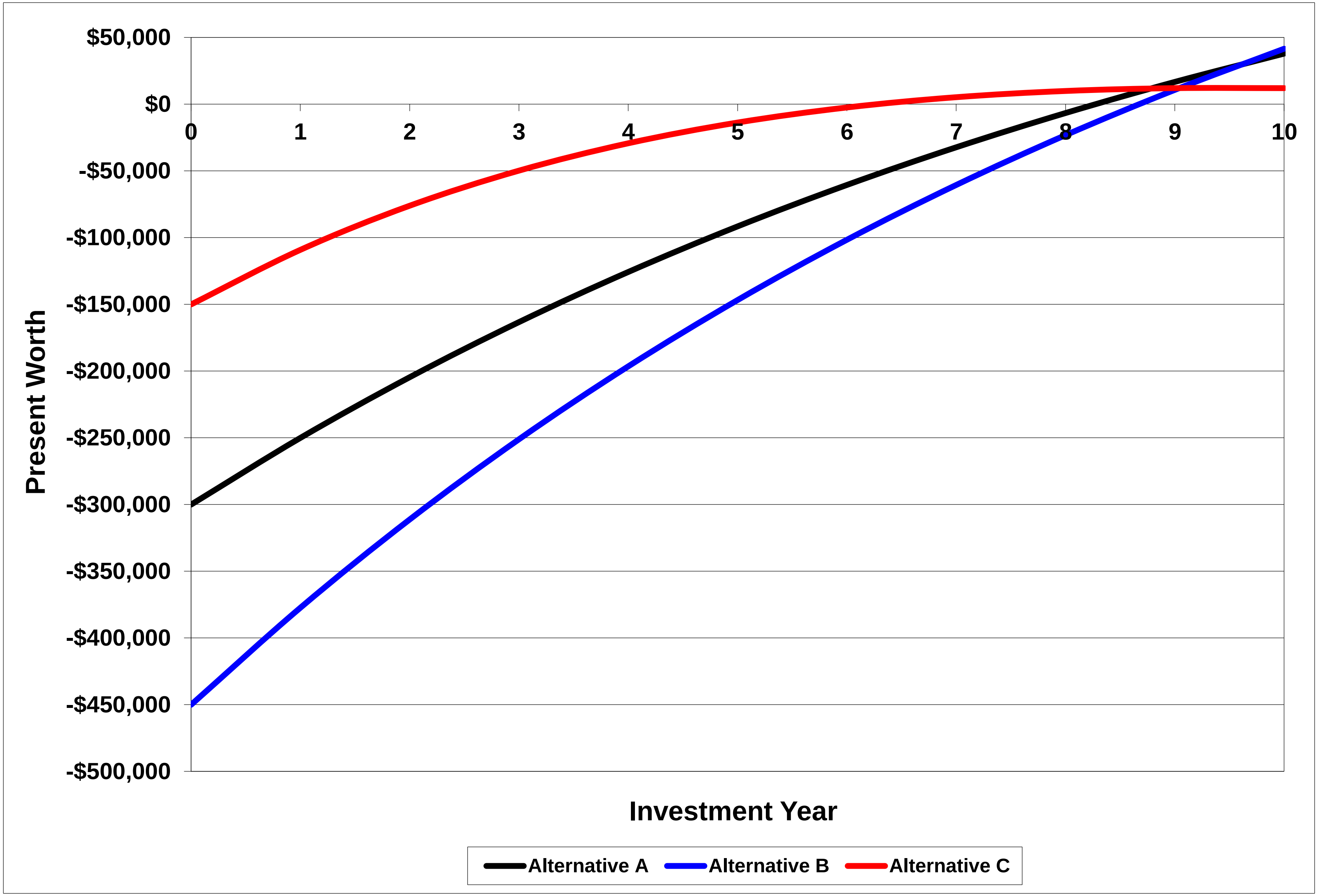
$DPBP_A$(10%) =NPER(10%,-55000,300000) = 8.273 years

$DPBP_B$(10%) =NPER(10%,-80000,450000) = 8.674 years

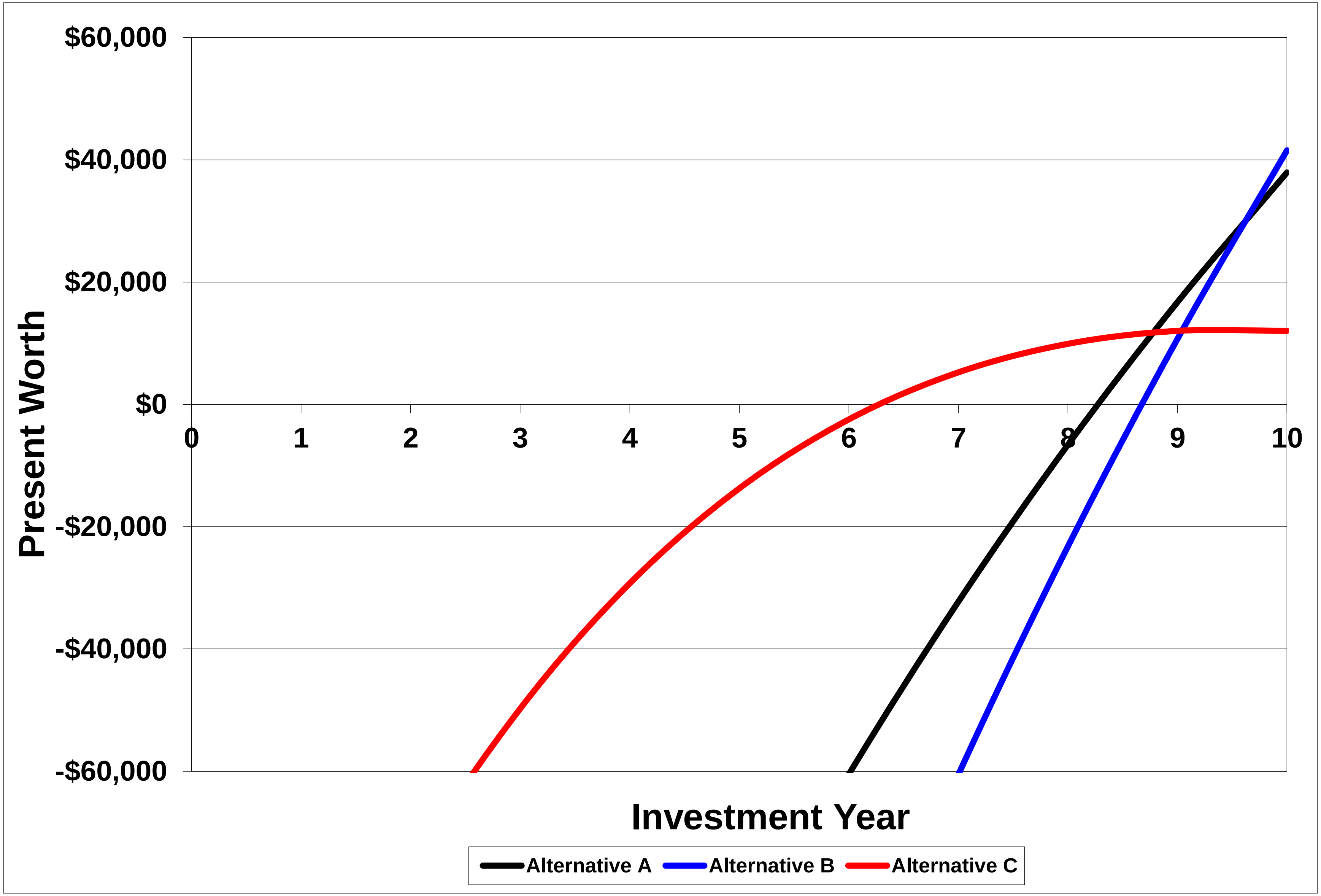
$DPBP_C$(10%) = 6.273 years (using the Excel® SOLVER tool)

	EOY	CF	Cum (PW)	EOY	CF	Cum (PW)	EOY	CF	Cum (PW)
		Alternative A			Alternative B			Alternative C	
	EOY	CF	Cum (PW)	EOY	CF	Cum (PW)	EOY	CF	Cum (PW)
	0	-$300,000	-$300,000	0	-$450,000	-$450,000	0	-$150,000	-$150,000
	1	$55,000	-$250,000	1	$80,000	-$377,273	1	$45,000	-$109,091
	2	$55,000	-$204,545	2	$80,000	-$311,157	2	$40,000	-$76,033
	3	$55,000	-$163,223	3	$80,000	-$251,052	3	$35,000	-$49,737
	4	$55,000	-$125,657	4	$80,000	-$196,411	4	$30,000	-$29,247
	5	$55,000	-$91,507	5	$80,000	-$146,737	5	$25,000	-$13,724
	6	$55,000	-$60,461	6	$80,000	-$101,579	6	$20,000	-$2,434
	7	$55,000	-$32,237	7	$80,000	-$60,526	7	$15,000	$5,263
	8	$55,000	-$6,579	8	$80,000	-$23,206	8	$10,000	$9,928
	9	$55,000	$16,746	9	$80,000	$10,722	9	$5,000	$12,049
	10	$55,000	$37,951	10	$80,000	$41,565	10	$0	$12,049
DPBP	8.282			8.684			6.316		

Present Worth as a Function of Investment Duration



Close-Up of Critical Region



Example 5.9

Now, suppose a third design (alternative C) is developed for The Scream Machine. As before, A requires a $300,000 investment and produces revenue of $55,000/yr; and B requires a $450,000 investment and produces revenue of $80,000/yr. The new design (C) requires a $150,000 investment and produces 1st year revenue of $45,000; thereafter, revenue decreases by $5000/yr. Based on a 10% *MARR*, which design has the smallest DPBP? (See the differences)

$DPBP_A$(10%) =NPER(10%,-55000,300000) = 8.273 years

$DPBP_B$(10%) =NPER(10%,-80000,450000) = 8.674 years

$DPBP_C$(10%) = 6.273 years (using SOLVER)

Note: PW_C(10%) = -$150,000 + $45,000(P|A 10%,10) - $5,000(P|G 10%,10)

PW_C(10%) = $12,048.81 < PW_A(10%) < PW_B(10%) B is best, not C!!

Example 5.10

Three investments are available, but only one can be pursued: invest $10,000 and obtain $5,000/yr for 2 yrs, plus $1,000 after 5 yrs; invest $10,000 and receive $5,000, $4,000, $3,000, $2,000, and $1,000 over the next 5 yrs; invest $10,000 and receive $2,500/yr for 5 yrs, plus $10,000 after 5 yrs. Which is best using PBP? using PW and a MARR of 10%?

EOY	CF(1)	CumCF(1)	CF(2)	CumCF(2)	CF(3)	CumCF(3)
0	**-$10,000**	**-$10,000**	**-$10,000**	**-$10,000**	**-$10,000**	**-$10,000**
1	**$5,000**	**-$5,000**	**$5,000**	**-$5,000**	**$2,500**	**-$7,500**
2	**$5,000**	**$0**	**$4,000**	**-$1,000**	**$2,500**	**-$5,000**
3	**$0**	**$0**	**$3,000**	**$2,000**	**$2,500**	**-$2,500**
4	**$0**	**$0**	**$2,000**	**$4,000**	**$2,500**	**$0**
5	**$1,000**	**$1,000**	**$1,000**	**$5,000**	**$12,500**	**$12,500**
***PBP* =**		**2 yrs**		**2.33 yrs**		**4 yrs**
***PW* (10%) =**	**-$701.39**		**$2,092.13**		**$5,686.18**	

PBP ranking: 1, 2, 3

PW ranking: 3, 2, 1

Capitalized Worth Analysis

Single Alternative

Capitalized Worth Method

- a perpetuity is an investment that has an infinite life
- the capitalized worth is the present worth of a perpetuity
- the capitalized worth indicates the amount of money needed "up front" such that the interest earned will cover the cash flow requirements forever for the investment
- used mostly by government

$$CW(i) = AW(i)/i$$

Example 5.13

How much will it cost to endow a $12,500 per year scholarship if the endowment earns 4.5% interest?

CW = $12,500/0.045 = $277,777.78

Example 5.11

Every 10 years the dome of the state capital building has to be cleaned, sand blasted, and re-touched. It costs $750,000 to complete the work. Using a 5% MARR, what is the capitalized cost for the refurbishment of the capital dome?

CC **= $750,000 + $750,000(P|F 5%,10) + $750,000(P|F 5%,10) + … (PW for infinite planning horizon)**

or

CC **= $750,000(A|P 5%,10)/0.05 = $750,000(0.1295)/0.05 = $1,942,500**

CC **=PMT(5%,10,-750000)/0.05 = $1,942,569 (convert the CF to annual divided by interest rate)**

or

CC **= $750,000 + $750,000(A|F 5%,10)/0.05 (AW/MARR)**

= $750,000 + $750,000(0.0795)/0.05 = $1,942,500

CC **=750000+PMT(5%,10,,-750000)/0.05 = $1,942,569**

Recall, *(A|P i%,n) = (A|F i%,n) + i*

Example 5.12

A new highway is to be constructed. Asphalt paving will be used. The asphalt will cost $150/ft, including the material and paving operation. Due to heavy usage, the asphalt is expected to last 5 yrs before requiring resurfacing.

The cost of resurfacing will be the same/ft. Paved ditches must be installed on each side of the highway and will cost $7.75/ft to install; ditches will have to be re-paved in 15 yrs at a cost equal to the initial cost. Four pipe culverts are required/mile; each costs $8,000 and will last 10 yrs; replacements will cost $10,000, each, forever. Annual maintenance of the highway will cost $9,000/mi. Cleaning each culvert will cost $1,250/yr.

Cleaning and maintaining each ditch will cost $3.75/ft every year. Using a 5% MARR, what is the capitalized cost (*CC*) per mile for the highway?

Example 5.12 (Solution)

Paving Highway and Ditches/mile

CC = 5,280 ft/mi[$150/ft(A|P 5%,5) + $7.75/ft(A|P 5%,15)]/0.05

= $3,737,409

=5280*(PMT(5%,5,-150)+PMT(5%,15,-7.75))/0.05 = $3,737,487

Highway Maintenance/mile

CC = $9,000/0.05 = $180,000

Ditch Maintenance/mile

CC = 2(5,280 ft/mi)($3.75/ft)/0.05 = $792,000

Culverts/mile

CC = 4[($8,000 + $1,250/0.05 + $10,000(A|F 5%,10)/0.05]

= $195,600

=4*(8000+1250/0.05+PMT(5%,10,,-10000)/0.05)

= $195,604

Highway/mile

CC = $3,737,487 + $180,000 + $792,000 + $195,604

= $4,905,091

Example 5.14

Suppose, instead of endowing a scholarship, you wish to establish a fund that will pay for the cost of a scholarship for 100 years. How much must you contribute to a fund that earns interest at an annual rate of 9%, if the size of the scholarship grows at an annual rate of 4.5%?

Chapter 5 tables and figures (11-13-08) [Compatibility Mode] - Microsoft Excel

L29 =L28*(1+$H$1)-K29

Beginning Scholarship Amount = $12,500.00   Annual Endowment Growth Rate = 9.0%

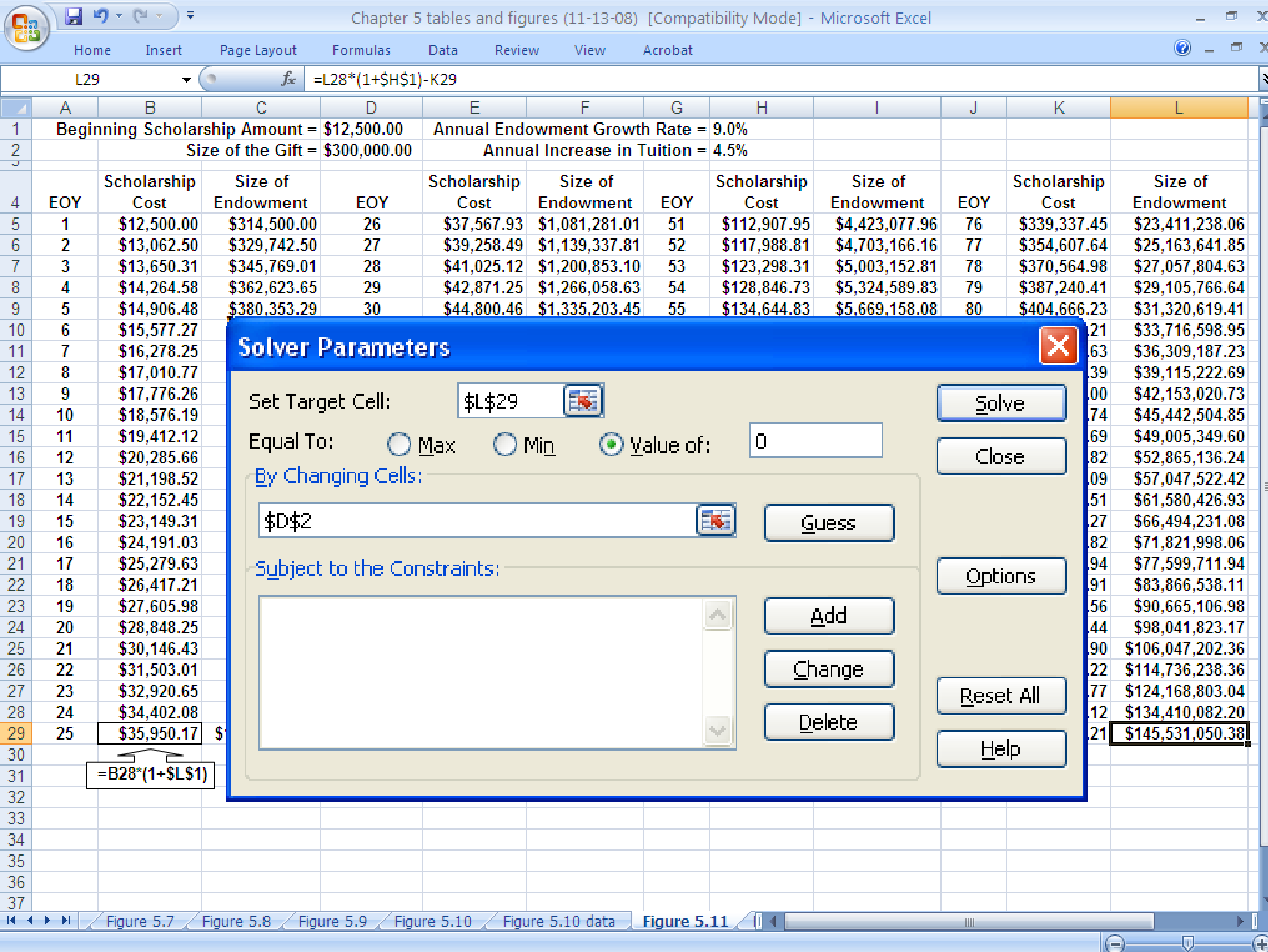
Size of the Gift = $300,000.00   Annual Increase in Tuition = 4.5%

EOY	Scholarship Cost	Size of Endowment	EOY	Scholarship Cost	Size of Endowment	EOY	Scholarship Cost	Size of Endowment	EOY	Scholarship Cost	Size of Endowment
1	$12,500.00	$314,500.00	26	$37,567.93	$1,081,281.01	51	$112,907.95	$4,423,077.96	76	$339,337.45	$23,411,238.06
2	$13,062.50	$329,742.50	27	$39,258.49	$1,139,337.81	52	$117,988.81	$4,703,166.16	77	$354,607.64	$25,163,641.85
3	$13,650.31	$345,769.01	28	$41,025.12	$1,200,853.10	53	$123,298.31	$5,003,152.81	78	$370,564.98	$27,057,804.63
4	$14,264.58	$362,623.65	29	$42,871.25	$1,266,058.63	54	$128,846.73	$5,324,589.83	79	$387,240.41	$29,105,766.64
5	$14,906.48	$380,353.29	30	$44,800.46	$1,335,203.45	55	$134,644.83	$5,669,158.08	80	$404,666.23	$31,320,619.41
6	$15,577.27	$399,007.81	31	$46,816.48	$1,408,555.28	56	$140,703.85	$6,038,678.46	81	$422,876.21	$33,716,598.95
7	$16,278.25	$418,640.27	32	$48,923.22	$1,486,402.04	57	$147,035.53	$6,435,123.99	82	$441,905.63	$36,309,187.23
8	$17,010.77	$439,307.12	33	$51,124.76	$1,569,053.46	58	$153,652.12	$6,860,633.03	83	$461,791.39	$39,115,222.69
9	$17,776.26	$461,068.50	34	$53,425.38	$1,656,842.89	59	$160,566.47	$7,317,523.53	84	$482,572.00	$42,153,020.73
10	$18,576.19	$483,988.48	35	$55,829.52	$1,750,129.23	60	$167,791.96	$7,808,308.69	85	$504,287.74	$45,442,504.85
11	$19,412.12	$508,135.32	36	$58,341.85	$1,849,299.02	61	$175,342.60	$8,335,713.87	86	$526,980.69	$49,005,349.60
12	$20,285.66	$533,581.84	37	$60,967.23	$1,954,768.70	62	$183,233.02	$8,902,695.11	87	$550,694.82	$52,865,136.24
13	$21,198.52	$560,405.69	38	$63,710.76	$2,066,987.13	63	$191,478.50	$9,512,459.16	88	$575,476.09	$57,047,522.42
14	$22,152.45	$588,689.75	39	$66,577.74	$2,186,438.23	64	$200,095.03	$10,168,485.45	89	$601,372.51	$61,580,426.93
15	$23,149.31	$618,522.51	40	$69,573.74	$2,313,643.93	65	$209,099.31	$10,874,549.83	90	$628,434.27	$66,494,231.08
16	$24,191.03	$649,998.51	41	$72,704.56	$2,449,167.33	66	$218,508.78	$11,634,750.54	91	$656,713.82	$71,821,998.06
17	$25,279.63	$683,218.75	42	$75,976.26	$2,593,616.12	67	$228,341.68	$12,453,536.41	92	$686,265.94	$77,599,711.94
18	$26,417.21	$718,291.22	43	$79,395.19	$2,747,646.38	68	$238,617.05	$13,335,737.64	93	$717,147.91	$83,866,538.11
19	$27,605.98	$755,331.45	44	$82,967.98	$2,911,966.58	69	$249,354.82	$14,286,599.21	94	$749,419.56	$90,665,106.98
20	$28,848.25	$794,463.02	45	$86,701.54	$3,087,342.03	70	$260,575.78	$15,311,817.35	95	$783,143.44	$98,041,823.17
21	$30,146.43	$835,818.27	46	$90,603.11	$3,274,599.71	71	$272,301.69	$16,417,579.22	96	$818,384.90	$106,047,202.36
22	$31,503.01	$879,538.90	47	$94,680.25	$3,474,633.44	72	$284,555.27	$17,610,606.08	97	$855,212.22	$114,736,238.36
23	$32,920.65	$925,776.75	48	$98,940.86	$3,688,409.59	73	$297,360.26	$18,898,200.37	98	$893,696.77	$124,168,803.04
24	$34,402.08	$974,694.58	49	$103,393.19	$3,916,973.26	74	$310,741.47	$20,288,296.93	99	$933,913.12	$134,410,082.20
25	$35,950.17	$1,026,466.92	50	$108,045.89	$4,161,454.97	75	$324,724.84	$21,789,518.82	100	$975,939.21	$145,531,050.38

=B28*(1+$L$1)

=L28*1.09-H29

Figure 5.7 | Figure 5.8 | Figure 5.9 | Figure 5.10 | Figure 5.10 data | Figure 5.11


Chapter 5 tables and figures (11-13-08) [Compatibility Mode] - Microsoft Excel
L29
=L28*(1+$H$1)-K29
Beginning Scholarship Amount = $12,500.00
Size of the Gift = $300,000.00
Annual Endowment Growth Rate = 9.0%
Annual Increase in Tuition = 4.5%
EOY
Scholarship Cost
Size of Endowment
=B28*(1+$L$1)
Solver Parameters
Set Target Cell: $L$29
Equal To: Max Min Value of: 0
By Changing Cells:
$D$2
Subject to the Constraints:
Solve
Close
Guess
Options
Add
Change
Delete
Reset All
Help
Figure 5.7
Figure 5.8
Figure 5.9
Figure 5.10
Figure 5.10 data
Figure 5.11

Chapter 5 tables and figures (11-13-08) [Compatibility Mode] - Microsoft Excel

Home | Insert | Page Layout | Formulas | Data | Review | View | Acrobat

L29 | =L28*(1+$H$1)-K29

Beginning Scholarship Amount = $12,500.00 | Annual Endowment Growth Rate = 9.0%

Size of the Gift = $273,678.79 | Annual Increase in Tuition = 4.5%

EOY	Scholarship Cost	Size of Endowment	EOY	Scholarship Cost	Size of Endowment	EOY	Scholarship Cost	Size of Endowment	EOY	Scholarship Cost	Size of Endowment
1	$12,500.00	$285,809.88	26	$37,567.93	$833,883.79	51	$112,907.95	$2,289,751.77	76	$339,337.45	$5,015,394.26
2	$13,062.50	$298,470.27	27	$39,258.49	$869,674.84	52	$117,988.81	$2,377,840.62	77	$354,607.64	$5,112,172.10
3	$13,650.31	$311,682.28	28	$41,025.12	$906,920.46	53	$123,298.31	$2,468,547.97	78	$370,564.98	$5,201,702.61
4	$14,264.58	$325,469.11	29	$42,871.25	$945,672.05	54	$128,846.73	$2,561,870.55	79	$387,240.41	$5,282,615.44
5	$14,906.48	$339,854.85	30	$44,800.46	$985,982.08	55	$134,644.83	$2,657,794.07	80	$404,666.23	$5,353,384.60
6	$15,577.27	$354,864.51	31	$46,816.48	$1,027,903.99	56	$140,703.85	$2,756,291.68	81	$422,876.21	$5,412,313.01
7	$16,278.25	$370,524.06	32	$48,923.22	$1,071,492.13	57	$147,035.53	$2,857,322.41	82	$441,905.63	$5,457,515.55
8	$17,010.77	$386,860.46	33	$51,124.76	$1,116,801.66	58	$153,652.12	$2,960,829.30	83	$461,791.39	$5,486,900.56
9	$17,776.26	$403,901.64	34	$53,425.38	$1,163,888.43	59	$160,566.47	$3,066,737.47	84	$482,572.00	$5,498,149.61
10	$18,576.19	$421,676.60	35	$55,829.52	$1,212,808.87	60	$167,791.96	$3,174,951.88	85	$504,287.74	$5,488,695.33
11	$19,412.12	$440,215.37	36	$58,341.85	$1,263,619.82	61	$175,342.60	$3,285,354.95	86	$526,980.69	$5,455,697.22
12	$20,285.66	$459,549.09	37	$60,967.23	$1,316,378.38	62	$183,233.02	$3,397,803.88	87	$550,694.82	$5,396,015.15
13	$21,198.52	$479,709.99	38	$63,710.76	$1,371,141.68	63	$191,478.50	$3,512,127.72	88	$575,476.09	$5,306,180.43
14	$22,152.45	$500,731.44	39	$66,577.74	$1,427,966.69	64	$200,095.03	$3,628,124.19	89	$601,372.51	$5,182,364.16
15	$23,149.31	$522,647.96	40	$69,573.74	$1,486,909.95	65	$209,099.31	$3,745,556.05	90	$628,434.27	$5,020,342.66
16	$24,191.03	$545,495.25	41	$72,704.56	$1,548,027.29	66	$218,508.78	$3,864,147.32	91	$656,713.82	$4,815,459.68
17	$25,279.63	$569,310.19	42	$75,976.26	$1,611,373.48	67	$228,341.68	$3,983,578.90	92	$686,265.94	$4,562,585.11
18	$26,417.21	$594,130.90	43	$79,395.19	$1,677,001.90	68	$238,617.05	$4,103,483.95	93	$717,147.91	$4,256,069.87
19	$27,605.98	$619,996.70	44	$82,967.98	$1,744,964.10	69	$249,354.82	$4,223,442.69	94	$749,419.56	$3,889,696.59
20	$28,848.25	$646,948.14	45	$86,701.54	$1,815,309.33	70	$260,575.78	$4,342,976.74	95	$783,143.44	$3,456,625.85
21	$30,146.43	$675,027.05	46	$90,603.11	$1,888,084.06	71	$272,301.69	$4,461,542.96	96	$818,384.90	$2,949,337.28
22	$31,503.01	$704,276.47	47	$94,680.25	$1,963,331.38	72	$284,555.27	$4,578,526.55	97	$855,212.22	$2,359,565.42
23	$32,920.65	$734,740.70	48	$98,940.86	$2,041,090.35	73	$297,360.26	$4,693,233.68	98	$893,696.77	$1,678,229.54
24	$34,402.08	$766,465.29	49	$103,393.19	$2,121,395.29	74	$310,741.47	$4,804,883.25	99	$933,913.12	$895,357.07
25	$35,950.17	$799,496.99	50	$108,045.89	$2,204,274.98	75	$324,724.84	$4,912,597.90	100	$975,939.21	$0.00

=B28*(1+$L$1)

=L28*1.09-H29

Figure 5.7 | Figure 5.8 | Figure 5.9 | Figure 5.10 | Figure 5.10 data | Figure 5.11

Capitalized Worth Analysis

Multiple Alternatives

Example 5.15

In a developing country, two alternatives are being considered for delivering water from a mountainous area to an arid area. A pipeline can be installed at a cost of $125 million; major replacements every 15 years will cost $10 million. Annual O&M costs are estimated to be $5 million. Alternately, a canal can be constructed at a cost of $200 million; annual O&M costs are estimated to be $1 million; upgrades of the canal will be required every 10 years at a cost of $5 million. Using a 5% MARR and a capitalized cost analysis, which alternative should be chosen?

Example 5.15 (Solution)

Pipeline

CC = $125,000,000 + [$10,000,000(A|F 5%,15)
+ $5,000,000]/0.05 = $234,268,000.00

=125000000+(PMT(5%,15,,-10000000)+5000000)/0.05

= $234,268,457.52

Canal

CC = $200,000,000 + [$5,000,000(A|F 5%,10)
+ $1,000,000]/0.05 = $227,950,000.00

= 200000000+(PMT(5%,10,,-5000000)+1000000)/.05

CC = $227,950,457.50

Pit Stop #5— Open Road Ahead!

1. True or False: Present worth analysis is the most popular *DCF* measure of economic worth.
2. True or False: Unless non-monetary considerations dictate otherwise, choose the mutually exclusive investment alternative that has the greatest present worth, regardless of the lives of the alternatives.
3. True or False: When using present worth analysis to evaluate the economic viability of mutually exclusive alternatives, use a common period of time in the comparison.
4. True or False: If *PW* > 0 and *MARR* = 20%, then *DPBP* < 5 years.
5. True or False: *DPBP* ≥ *PBP.*
6. True or False: If *CW* > 0, then *PW* > 0.
7. True or False: If *PW*(A) > *PW*(B), then *CW*(A) > *CW*(B), *DPBP*(A) < *DPBP*(B), and *PBP*(A) < *PBP*(B).
8. True or False: *PW*, *FW, AW, CW,* and *B/C* are ranking methods; therefore, the alternative having the greatest *PW*, *FW, AW, CW,* or *B/C* should be recommended.
9. True or False: Either ranking or incremental analysis can be used with all four "worth" methods (*PW*, *FW, AW,* and *CW*).
10. True or False: The "do nothing" alternative always has negligible incremental costs and revenues.

Pit Stop #5— Open Road Ahead!

1. True or False: Present worth analysis is the most popular *DCF* measure of economic worth. TRUE
2. True or False: Unless non-monetary considerations dictate otherwise, choose the mutually exclusive investment alternative that has the greatest present worth, regardless of the lives of the alternatives. FALSE
3. True or False: When using present worth analysis to evaluate the economic viability of mutually exclusive alternatives, use a common period of time in the comparison. TRUE
4. True or False: If *PW* > 0 and *MARR* = 20%, then *DPBP* < 5 years. FALSE
5. True or False: *DPBP* ≥ *PBP.* TRUE
6. True or False: If *CW* > 0, then *PW* > 0. TRUE
7. True or False: If *PW*(A) > *PW*(B), then *CW*(A) > *CW*(B), *DPBP*(A) < *DPBP*(B), and *PBP*(A) < *PBP*(B). FALSE (NOT ALWAYS)
8. True or False: *PW*, *FW, AW, CW,* and *B/C* are ranking methods; therefore, the alternative having the greatest *PW*, *FW, AW, CW,* or *B/C* should be recommended. FALSE
9. True or False: Either ranking or incremental analysis can be used with all four "worth" methods (*PW*, *FW, AW,* and *CW*). TRUE
10. True or False: The "do nothing" alternative always has negligible incremental costs and revenues. FALSE