Solution Manual Engineering Economy 16th Edition William G. Sullivan, Elin M. Wicks, C. Patrick Koelling

Solutions to Chapter 6 Problems

6-1

EOY	Alt.B	Alt. A	Δ(B-A)
0	-$5,000	-$3,500	-$1,500
1	1,480	1,255	225
2	1,480	1,255	225
3	1,480	1,255	225
4	1,480	-2,245	3,725
5	1,480	1,255	225
6	-3,520	1,255	-4,775
7	1,480	1,255	225
8	1,480	-2,245	3,725
9	1,480	1,255	225
10	1,480	1,255	225
11	1,480	1,255	225
12	1,480	1,255	225

According to Descartes' Rule and Nordstrom's Rule, a maximum of three interest rates exist for the above incremental cash flows. In the interval 0%-100%, there is only a single unique internal rate of return, which equals 26%. This can be seen from the following:

i	PW (B-A)	
1%	2,918	
10%	1,234	
20%	326]	IRR = 26%
30%	-164]	
40%	-463	
50%	-665	
60%	-809	
70%	-917	
80%	-1001	
90%	-1,067	
100%	-1,121	

6-2 Present Worth Method, MARR = 10% per year

PW_{D1} (10%) = −\$600,000 − \$780,000(P/A,10%,8) = −\$4,761,222

PW_{D2} (10%) = −\$760,000 − \$728,000(P/A,10%,8) = −\$4,643,807

PW_{D3} (10%) = −\$1,240,000 − \$630,000(P/A,10%,8) = −\$4,600,987

PW_{D4} (10%) = −\$1,600,000 − \$574,000(P/A,10%,8) = −\$4,662,233

Select Design D3 to minimize the present worth of costs.

Future Worth Method, MARR = 10% per year

FW_{D1} (10%) = −\$600,000(F/P,10%,8) − \$780,000(F/A,10%,8) = −\$10,206,162

FW_{D2} (10%) = −\$760,000(F/P,10%,8) − \$728,000(F/A,10%,8) = −\$9,954,471

FW_{D3} (10%) = −\$1,240,000(F/P,10%,8) − \$630,000(F/A,10%,8) = −\$9,862,681

FW_{D4} (10%) = −\$1,600,000 (F/P,10%,8) – \$574,000(F/A,10%,8) = −\$9,993,967

Select Design D3 to minimize the future worth of costs.

Annual Worth Method, MARR = 1% per year

AW_{D1} (10%) = −\$600,000 (A/P,10%,8) – \$780,000 = −\$892,440

AW_{D2} (10%) = −\$760,000 (A/P,10%,8) – \$728,000 = −\$870,424

AW_{D3} (10%) = −\$1,240,000 (A/P,10%,8) – \$630,000 = −\$862,376

AW_{D4} (10%) = −\$1,600,000 (A/P,10%,8) – \$574,000 = −\$873,840

Select Design D3 to minimize the annual worth of costs.

6-3 Don't be tempted to choose the project that maximizes the IRR! In this problem we should recommend Project R15 because it has a larger PW (12%) than Project S19.

6-4 Assume all units are produced and sold each year.

$AW_A(20\%) = -\$30,000(A/P,20\%,10) + 15,000(\$3.50 - \$1.00) - \$15,000 = \$15,345$

$AW_B(20\%) = -\$60,000(A/P,20\%,10) + 20,000(\$4.40 - \$1.40) - \$30,000 + \$20,000(A/F,20\%,10)$
$= \$16,460$

$AW_C(20\%) = -\$50,000(A/P,20\%,10) + 18,000(\$4.10 - \$1.15) - \$25,000 + \$15,000(A/F,20\%,10)$
$= \$15,753$

Select Design B to maximize the annual worth.

6-5 Let's examine this problem incrementally. The labor savings for the new system are 32 hours per month (which is 20% of 160 hours per month for the used system) x \$40 per hour = \$1,280 per month. The additional investment for the new system is \$75,000, and the incremental market value after five years is \$30,000. So we have:

$$PW(\text{of difference at 1\% per month}) = -\$75,000 + \$1,280\,(P/A, 1\%, 60) + \$30,000\,(P/F, 1\%, 60) = -\$946$$

The extra investment for the new system is not justified. But the margin in favor of the used system is quite small, so management may select the new system because of intangible factors (improved reliability, improved image due to new technology, etc.).

6-6 Wet Tower, Mechanical Draft

AW(12%) = −\$3,000,000 (A/P,12%,30)

$$-40\left(\frac{200hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760 \text{ hr/yr})\ (\$0.022/\text{kWh})$$

$$-20\left(\frac{150hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760 \text{ hr/yr})\ (\$0.022/\text{kWh}) - \$150{,}000$$

= −\$372,300 − \$1,277,948 − \$479,230 − \$150,000 = <u>−\$2,279,478/yr.</u>

Wet Tower, Natural Draft

AW(12%) = −\$8,700,00(A/P,12%,30)

$$-20\left(\frac{150hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760 \text{ hr/yr})\ (\$0.022/\text{kWh}) - \$100{,}000$$

− \$1,076,670 − \$479,230 − \$100,000 = −<u>\$1,658,900/yr.</u>

Dry Tower, Mechanical Draft

AW(12%) = −\$5,100,000(A/P,12%,30)

$$-20\left(\frac{200hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760 \text{ hr/yr})\ (\$0.022/\text{kWh})$$

$$-40\left(\frac{100hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760 \text{ hr/yr})\ (\$0.022/\text{kWh}) - \$170{,}000$$

= −\$632,910 − \$638,974 − \$638,974 − \$170,000 <u>−\$2,080,858/yr.</u>

Dry Tower, Natural Draft

AW(12%) = −\$9,000,000(A/P,12%,30)

$$-40\left(\frac{100hp}{0.9}\right)\left(\frac{0.746kw}{hp}\right)(8{,}760 \text{ hr/yr})\ (\$0.022/\text{kWh}) - \$120{,}000$$

= −\$1,116,900 − \$638,974 − \$120,000 = <u>−\$1,875,874/yr.</u>

The wet cooling tower with natural draft heat removal from the condenser water is the most economical (i.e., least costly) alternative.

Non−economic factors include operating considerations and licensing the plant in a given location with its unique environmental characteristics.

6-7 $PW_A(20\%) = -\$28,000 + (\$23,000 - \$15,000)(P/A,20\%,10) + \$6,000(P/F,20\%,10)$
$= \$6,509$

$PW_B(20\%) = -\$55,000 + (\$28,000 - \$13,000)(P/A,20\%,10) + \$8,000(P/F,20\%,10)$
$= \$\underline{9,180}$

$PW_C(20\%) = -\$40,000 + (\$32,000 - \$22,000)(P/A,20\%,10) + \$10,000(P/F,20\%,10)$
$= \$3,540$

Select Alternative B to maximize present worth.

Note: If you were to pick the alternative with the highest total IRR, you would have incorrectly selected Alternative A.

6-8 ILB: Installation cost is \$2,000 plus the cost of the bulbs (\$500) for an investment cost of \$2,500. This is assumed to occur at the beginning of each year in the 8-year study period. The cost of electricity for 60,000 kWh at \$0.12 per kWh is \$7,200 per year. Let's assume that the electricity expense is incurred at the end of each year for eight years:

$$PW(12\%) = -\$2{,}500 - \$2{,}500(P/A, 12\%, 7) - \$7{,}200(P/A, 12\%, 8) = -\$49{,}677$$

CFL: Installation cost is \$3,000 plus the cost of the 1,000 CFLs for a total investment cost of \$5,000. This is assumed to be incurred at the beginning of the 8-year study period. The cost of electricity for 13,000 kWh at \$0.12 per kWh is \$1,560 at the end of each year for eight years:

$$PW(12\%) = -\$5{,}000 - \$1{,}560(P/A, 12\%, 8) = -\$12{,}749$$

The boss will be happy to learn that CFLs offer tremendous cost savings over the ILBs. CFLs cost about 26% of the PW of cost of the ILBs over the 8-year study period. A side note: In Europe ILBs will not be sold in stores beginning in September of 2009. ILBs are simply too energy inefficient and create too much of a carbon footprint! Let's become "enlightened" and make the change.

6-9 Jean's future worth at age 65 will be $1,000 (F/A, 6%, 10) (F/P, 6%, 25) = $56,571. Doug's future worth will be $1,000 (F/A, 6%, 25) = $54,865. Jean's future worth will be greater than Doug's even though she stopped making payments into her plan before Doug started making payments into his plan! The moral is to start saving for retirement at an early age (the earlier the better).

6-10 We can examine the incremental cash flows (R − O) to determine the IRR on this difference, Δ(R − O):

EOY	Δ(R−O)
0	-$6,000
1	0
2	0
3	11,718

The IRR on the incremental cash flow is 25%, so recommend the rectangular re-bar. This can be confirmed by computing the PW (25%) of each alternative: PW of O equals $729 and PW of R equals $1,510

6-11 Tool B should not be considered further since its IRR < 8%.

$$PW_A = -\$55,000 + (\$18,250 - \$6,250)(P/A, 8\%, 7) + \$18,000(P/F, 8\%, 7) = \$17,980$$

$$PW_C = -\$80,000 + (\$20,200 - \$3,200)(P/A, 8\%, 7) + \$22,000(P/F, 8\%, 7) = \$21,346$$

Select Tool C.

6-12 Design A: All components have a 20 year life.

Capital Investment

Concrete pavement: (\$90/ft)(5,280 ft/mi)	= \$475,200 /mile
Paved ditches: 2×(\$3/ft)(5,280 ft/mi)	= \$31,680 /mile
Box culverts: (3 culverts/mile)(\$9,000/culvert)	= \$27,000 /mile
Total Capital Investment	= \$533,880 /mile

Maintenance

Annual maintenance: \$1,800 /mile

Periodic cleaning of culverts*:

(3 culverts/mile)(\$450/culvert) = \$1,350 /mile every 5 years

$AW_A(6\%) = -\$533,880(A/P,6\%,20) - \$1,800 - \$1,350(A/F,6\%,5)^* = -\$48,594$ /mile

$PW_A(6\%) = -\$533,880 - [\$1,800 + \$1,350(A/F,6\%,5)](P/A,6\%,20) = -\$557,273$ /mile

* assumes a cleaning also occurs at the end of year 20.

Design B: All components have a 10 year life.

Capital Investment (Year 0)

Bituminous pavement: (\$45/ft)(5,280 ft/mi)	= \$237,600 /mile
Sodded ditches: 2×(\$1.50/ft)(5,280 ft/mi)	= \$15,840 /mile
Pipe culverts: (3 culverts/mile)(\$2,250/culvert)	= \$6,750 /mile
Total	= \$260,190 /mile

Capital Investment (EOY 10)

Bituminous pavement: (\$45/ft)(5,280 ft/mi)	= \$237,600 /mile
Sodded ditches: 2×(\$1.50/ft)(5,280 ft/mi)	= \$15,840 /mile
Replacement culverts: (3 culverts/mile)(\$2,400/culvert)	= \$7,200 /mile
Total	= \$260,640 /mile

Maintenance

Annual pavement maintenance:	= \$2,700 /mile
Annual cleaning of culverts: (3 culverts/mile)(\$225/culvert)	= \$675 /mile
Annual ditch maintenance: 2×(\$1.50/ft)(5280 ft/mi)	= \$15,840 /mile
Total	= \$19,215 /mile

$AW_B(6\%) = -[\$260,190 + \$260,640(P/F,6\%,10)](A/P,6\%,20) - \$19,215 = -\$54,595$ /mile

$PW_B(6\%) = -\$260,190 - \$260,640(P/F,6\%,10) - \$19,215(P/A,6\%,20) = -\$626,126$ /mile

Select Design A (concrete pavement) to minimize costs.

6-13 Method: Incremental PW

Order alternatives by increasing capital investment: ER3, ER1, ER2.

Is ER3 an acceptable base alternative?

$PW_{ER3}(12\%) = -\$81,200 + \$19,750(P/A,12\%,6) = \$0.15 \approx 0.$

Since PW(MARR=12%) ≥ 0, ER3 is an acceptable base alternative.

Analyze Δ (ER1−ER3)

$$PW_{\Delta}(12\%) = -(\$98,600 - \$81,200) + \frac{\$25,800[1-(P/F,12\%,6)(F/P,6\%,6)]}{0.12-0.06} - \$19,750(P/A,12\%,6)$$

$$= -\$17,400 + \frac{\$25,800(0.2814)}{0.06} - \$19,750(4.1114)$$

$$= \$22,402 > 0$$

The additional capital investment earns more than the MARR. Therefore, design ER1 is preferred to design ER3.

Analyze Δ (ER2−ER1)

$$PW_{\Delta}(12\%) = -(\$115,000 - \$98,600) + \$29,000(P/A,12\%,6) + \$150(P/G,12\%,6) - \frac{\$25,800[1-(P/F,12\%,6)(F/P,6\%,6)]}{0.12-0.06}$$

$$= -\$16,400 + \$29,000(4.1114) + \$150(8.93) - \frac{\$25,800(0.2814)}{0.06}$$

$$= -\$16,832 < 0$$

The additional capital investment required by design ER2 has a negative PW (earns less than the MARR). Therefore, design ER1 is preferred to design ER2.

Decision: Recommend Design ER1

6-14 PW_A = \$15,500(P/A, 12%, 10) + \$500(P/G, 12%, 10) = \$97,705

PW_B = \$12,000(P/A, 12%, 10) + \$2,000(P/G, 12%, 10) = \$108,310

Based on property tax assessments, Parcel A is preferred to Parcel B.