Chapter 5 Present-Worth Analysis

5.1) (a), (b), (c)

n	Inflow	Outflow	Net Cash Flow
0	$0	$65,000	-$65,000
1	$215,500	$53,000	$162,550
2	$215,500	$53,000	$162,550
3	$215,500	$53,000	$162,550
4	$215,500	$53,000	$162,550
5	$215,500	$53,000	$162,550
6	$215,500	$53,000	$162,550
7	$215,500	$53,000	$162,550
8	$215,500	$53,000	$162,550

Annual cash inflow = $\$17\times 34,000 - \$15\times 30,000 + \$25\times 3,500 = \$215,500$

5.2) Project cash flows over the project life

n	Cmax	Demand	Revenue	Expense	Cost of Bldg.	NCF
0			-	-	1,527,776	-$1,527,776
1	6,000,000	3,000,000	16,256,976	6,462,108	-	9,794,868
2	6,000,000	3,300,000	17,882,673	7,096,319	-	10,786,354
3	6,000,000	3,630,000	19,670,941	7,793,951	-	11,876,990
4	6,000,000	3,993,000	21,638,035	8,561,346	-	13,076,689
5	6,000,000	4,392,300	23,801,838	9,405,481	-	14,396,358
6	6,000,000	4,831,530	26,182,022	10,334,029	1,545,123♠	14,302,870
7	12,000,000	5,314,683	28,800,224	11,355,432	-	17,444,793
8	12,000,000	5,846,151	31,680,247	12,478,975	-	19,201,272
9	12,000,000	6,430,766	34,848,271	13,714,872	-	21,133,399
10	12,000,000	7,073,843	38,333,099	15,074,359	-	23,258,739
11	12,000,000	7,781,227	42,166,408	16,569,795	-	25,596,613
12	12,000,000	8,559,350	46,383,049	18,214,775	-	28,168,274
13	12,000,000	9,415,285	51,021,354	20,024,252	-	30,997,102
14	12,000,000	10,356,814	56,123,490	22,014,678	1,573,302♠	32,535,510
15	24,000,000	11,392,495	61,735,839	24,204,145	-	37,531,693

♠: The cost of building is given as if C_{max} is being built from scratch. No “credit” is given for the capacity already in place. This assumption could be rather unrealistic. In that case, what we need to do is to identify the incremental cost of adding the additional capacity above the existing capacity.

5.3)

(a) Payback period: 1 years

n	Net Cash Flow	Cumulative CF
0	-$65,000	-$65,000
1	$162,500	$97,500
2	$162,500	$260,000
3	$162,500	$422,500
4	$162,500	$585,000
5	$162,500	$747,500
6	$162,500	$910,000
7	$162,500	$1,072,500
8	$162,500	$1,235,000

(b) Discounted payback period = 1 year.

n	Net Cash Flow	Cost of funds	Cumulative CF
0	-$65,000	$0	-$65,000
1	$162,500	-$9,750	$87,750
2	$162,500	$13,163	$263,413
3	$162,500	$39,512	$465,424
4	$162,500	$69,814	$697,738
5	$162,500	$104,661	$964,899
6	$162,500	$144,735	$1,272,134
7	$162,500	$190,820	$1,625,454
8	$162,500	$243,818	$2,031,772

5.4)

(a) It will take 3 years to recover the total investment.

n	Inflow	Outflow	Net Cash Flow	Cumulative CF
0	$0	$32,500	-$32,500	-$32,500
1	$12,000	$0	$12,000	-$20,500
2	$12,000	$0	$12,000	-$8,500
3	$12,000	$0	$12,000	$3,500
4	$12,000	$0	$12,000	$15,500
5	$17,000	$0	$17,000	$32,500

(b) It will take 4 years to recover the total investment.

n	Cash Flow	Cost of funds	Cumulative CF
0	-$32,500	$0	-$32,500
1	$12,000	-$4,550	-$25,050
2	$12,000	-$3,507	-$16,557
3	$12,000	-$2,318	-$6,875
4	$12,000	-$962	$4,163
5	$17,000	$583	$21,745

5.5)

(a) It will take 5 years to recover the total investment.

n	Cash Flow	Cumulative CF
0	-$10,000	-$10,000
1	-$15,000	-$25,000
2	$8,000	-$17,000
3	$8,000	-$9,000
4	$8,000	-$1,000
5	$8,000	$7,000

(b) The total investment is recovered in year 6 (or 5.19 years)

n	Cash Flow	Cost of funds (10%)	Cumulative CF

0	-$10,000	$0	-$10,000
1	-$15,000	-$1,000	-$26,000
2	$8,000	-$2,600	-$20,600
3	$8,000	-$2,060	-$14,660
4	$8,000	-$1,466	-$8,126
5	$8,000	-$813	-$939
6	$8,000	-$94	$6,968

5.6)

(a) Payback period

Project A: 5 years, Project B: 5 years, Project C: 4 years

	A		B		C		D	
n	CF	Cum.CF	CF	Cum.CF	CF	Cum.CF	CF	Cum.CF
0	-$1,500	-$1,500	-$6,000	-$6,000	-$10,000	-$10,000	-$4,500	-$4,500
1	200	-1,300	2,000	-4,000	2,000	-8,000	5,000	500
2	300	-1,000	1,500	-2,500	2,000	-6,000	3,000	3,500
3	400	-600	1,500	-1,000	2,000	-4,000	-4,000	-500
4	500	-100	500	-500	5,000	**1,000**	1,000	**500**
5	300	**200**	500	**0**	5,000	6,000	1,000	1,500
6	300	500	1,500	1,500			2,000	3,500
7	300	800					3,000	6,500
8	300	1,100						

(b) Project D does not have a unique payback period, as there are two payback periods—one at year 2 and the other at period 4. However, if the project is undertaken, we would say 4 years, because that is when the project truly is financially in the clear.

(c) Discounted payback period

Project A: 7 years, Project B: none, Project C: 5 years.

	A		B		C		D	
n	CF	Cum.CF	CF	Cum.CF	CF	Cum.CF	CF	Cum.CF
0	-$1,500	-$1,500	-$6,000	-$6,000	-$10,000	-$10,000	-$4,500	-$4,500

1	200	-1,450	2,000	-4,600	2,000	-9,000	5,000	50
2	300	-1,295	1,500	-3,560	2,000	-7,900	3,000	3,055
3	400	-1,025	1,500	-2,416	2,000	-6,690	-4,000	-640
4	500	-627	500	-2,158	5,000	-2,359	1,000	**297**
5	300	-390	500	-1,873	5,000	**2,405**	1,000	1,326
6	300	-129	1,500	-561			2,000	3,459
7	300	**159**					3,000	6,805
8	300	474						

5.7)

n	Cash Flow
0	-$18,000
1	$4,800
2	$6,350
3	$7,735
4	$7,500
5	$4,300
6	$7,000 + $1,800

$$\begin{aligned}\text{PW}(9\%) &= -\$18,000 + \$4,800(P/F,9\%,1) + \$6,350(P/F,9\%,2)\\ &\quad +\$7,735(P/F,9\%,3) + \$7,500(P/F,9\%,4)\\ &\quad +\$4,300(P/F,9\%,5) + \$8,800(P/F,9\%,6)\\ &= \$11,076.22\end{aligned}$$

5.8)

(a) There is an opportunity cost of $100,000 for land, which is tied up for this project. This cost should be viewed as an investment required undertaking the project. The $25,000 license fee is considered as one time up-front cost.

n	Inflow	Outflow	Net Cash Flow	Cumulative CF
0	$0	$1,625,000	-$1,625,000	-$1,625,000
1	$500,000	$240,000	$260,,000	-$1,365,000

2	\$500,000	\$240,000	\$260,000	-\$1,105,000
3	\$500,000	\$240,000	\$260,000	-\$845,000
4	\$500,000	\$240,000	\$260,000	-\$585,000
5	\$500,000	\$240,000	\$260,000	-\$325,000
6	\$734,010	\$240,000	\$494,010	\$169,010

- Inflow for year 6: \$500,000 + \$100,000(*F*/*P*, 5%, 6) = \$734,010
- Outflow for year 0: \$1,500,000 + \$100,000 + \$25,000 = \$1,625,000
- Outflow for years 1 - 6: (0.30 + 0.15 + 0.03)(\$500,000) = \$240,000

$$\begin{aligned}\text{PW}(15\%) &= -\$1,625,000 + \$260,000(P/A,15\%,5) + \$494,010(P/F,15\%,6) \\ &= -\$539,865 < 0\end{aligned}$$

(b) No discounted payback period exist as the initial investment is not fully recovered at the end of the project period (or PW(15%) < 0)

5.9)

(a)

$$\begin{aligned}\text{PW}(10\%)_A &= -\$800 + \$3,000(P/F,10\%,3) \\ &= \$1,453.9 \\ \text{PW}(10\%)_B &= -\$1,800 + \$600(P/F,10\%,1) \\ &\quad + \$900(P/F,10\%,2) + \$1,700(P/F,10\%,3) \\ &= \$766.49 \\ \text{PW}(10\%)_C &= -\$1,000 - \$1,200(P/F,10\%,1) \\ &\quad + \$900(P/F,10\%,2) + \$3,500(P/F,10\%,3) \\ &= \$1282.3 \\ \text{PW}(10\%)_D &= -\$6,000 + \$1,900(P/A,10\%,2) \\ &\quad + \$2,800(P/F,10\%,3) \\ &= -\$598.91\end{aligned}$$

(b) Not provided.

5.10)

n	Inflow	Outflow	Net Cash Flow	Cumulative CF
0	$0	$1,500,000	-$1,500,000	-$1,500,000
1	$227,000	$157,000	$70,000	-$1,430,000
2	$227,000	$157,000	$70,000	-$1,360,000
⋮	⋮	⋮	⋮	⋮
33	$227,000	$157,000	$70,000	$810,000
34	$227,000	$157,000	$70,000	$880,000
35	$452,000	$157,000	$295,000	$1,175,000

$$\begin{aligned} PW(12\%) &= -\$1{,}500{,}000 + \$70{,}000(P/A,12\%,34) + \$295{,}000(P/F,12\%,35) \\ &= -\$923{,}453 \end{aligned}$$

5.11)

Given: Estimated remaining service life $= 25$ years, current rental income $= \$250{,}000$ per year, O&M costs $= \$65{,}000$ for the first year increasing by \$6,000 thereafter, salvage value $= \$200{,}000$, and $\text{MARR} = 15\%$. Let A_0 be the maximum investment required to break even.

$$\begin{aligned} \text{PW}(15\%) &= \$250{,}000(P/A,15\%,5) + \$275{,}000(P/A,15\%,5)(P/F,15\%,5) \\ &+\$302{,}500(P/A,15\%,5)(P/F,15\%,10) \\ &+\$332{,}750(P/A,15\%,5)(P/F,15\%,15) \\ &+\$366{,}025(P/A,15\%,5)(P/F,15\%,20) \\ &-\$65{,}000(P/A,15\%,25) - \$6{,}000(P/G,15\%,25) + \$200{,}000(P/F,15\%,25) \\ &= \$1{,}116{,}775 \end{aligned}$$

5.12)

$$
\begin{aligned}
P &= -\$4,000 + \$3,400(P/F,9\%,1) \\
&\quad +\$3,400(P/F,12\%,1)(P/F,9\%,1) \\
&\quad +\$1,500(P/F,10\%,1)(P/F,12\%,1)(P/F,9\%,1) \\
&\quad +\$3,500(P/F,13\%,1)(P/F,10\%,1)(P/F,12\%,1)(P/F,9\%,1) \\
&\quad +\$4,300(P/F,12\%,1)(P/F,13\%,1)(P/F,10\%,1)(P/F,12\%,1)(P/F,9\%,1) \\
&= \$7,858.34
\end{aligned}
$$

5.13)

n	Inflow	Outflow	Net Cash Flow	Cumulative CF
0	$0	$250,000	-$250,000	-$250,000
1	$160,000	$50,000	$110,000	-$140,000
2	$160,000	$50,000	$110,000	-$30,000
3	$160,000	$50,000	$110,000	$80,000
4	$160,000	$50,000	$110,000	$190,000
5	$160,000	$50,000	$110,000	$300,000
6	$160,000	$50,000	$110,000	$410,000
7	$160,000	$50,000	$110,000	$520,000
8	$160,000	$50,000	$110,000	$630,000

$$
\begin{aligned}
\text{PW}(12\%) &= -\$250,000 + \$110,000(P/A,12\%,8) \\
&= \$296,440
\end{aligned}
$$

5.14)

Given: Initial cost $= \$3,000,000$, annual savings $= \$1,200,000$,
Annual O&M costs $= \$250,000$, annual income taxes $= \$150,000$,
Salvage value $= \$200,000$, useful life $= 10$ years, MARR $= 18\%$

$$
\begin{aligned}
\text{PW}(18\%) &= -\$3,000,000 \\
&\quad +[\$1,200,000 - \$250,000 \\
&\quad -\$150,000](P/A,18\%,10) \\
&\quad +\$200,000(P/F,18\%,10) \\
&= \$633,482
\end{aligned}
$$

The project is a profitable one.

5.15)

$$\begin{aligned}
\text{PW}(13\%)_A &= -\$5,000 + \$5,800(P/F,13\%,1) \\
&\quad +\$12,400(P/F,13\%,2) + \$8,200(P/F,13\%,3) \\
&= \$15,526.86 \\
\text{FW}(13\%)_A &= \$15,526.86(F/P,13\%,3) \\
&= \$22,403.88 \\
\text{PW}(13\%)_B &= -\$2,000 - \$4,400(P/F,13\%,1) \\
&\quad +\$7,000(P/F,13\%,2) + \$3,000(P/F,13\%,3) \\
&= \$1,667 \\
\text{FW}(13\%)_B &= \$1,667(F/P,13\%,3) = \$2,405.85 \\
\text{PW}(13\%)_C &= \$4,500 - \$6,000(P/F,13\%,1) \\
&\quad +\$2,000(P/F,13\%,2) + \$4,000(P/F,13\%,3) \\
&= \$3,528.6 \\
\text{FW}(13\%)_C &= \$3528.6(F/P,13\%,3) = 5,091.42 \\
\text{PW}(13\%)_D &= -\$3,500 + \$1,000(P/F,13\%,1) \\
&\quad +\$5,000(P/F,13\%,2) + \$6,000(P/F,13\%,3) \\
&= \$5,458.99 \\
\text{FW}(13\%)_D &= \$5,458.99(F/P,13\%,3) = \$7,876.76
\end{aligned}$$

5.16)

(a)

Year	Outflow
2008	$14,500,000
2009	$3,500,000
2010	$26,000,000

$$\begin{aligned}
\text{FW}(15\%) &= \$14,500,000(F/P,15\%,2) + \$3,500,000(F/P,15\%,1) \\
&\quad +\$26,000,000 \\
&= \$49,201,250
\end{aligned}$$

(b)

$$A(P/A,15\%,10) = FW(15\%)$$
$$= \$49,201,250$$
$$A(5.0188) = \$49,201,250$$
$$A = \$9,803,450$$

5.17)

$$\text{PB}(i)_1 = -\$1,000(1+i) + \$200 = -\$900$$
$$i = 10\%$$

5.18)

(a) In part (b), it is determined that I = 20%. Then, the original cash flows of the project is as follows:

n	A_n	Project Balance
0	-$1,000	-$1,000
1	$100	-$1,100
2	$520	-$800
3	$460	-$500
4	$600	$0

(b)

$$\text{PB}(i)_3 = -\$800(1+i) + \$460$$
$$= -\$500$$
$$-\$800i = -\$160$$
$$i = 20\%$$

(c) Yes

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5.19)

- For Project B:

  $$650(1+i)^{-2} = \$416$$

  $$i = 25\%$$

  Statement 3 is true.

- For Statement 1 to be true, I would have to equal 0%, since \$200(1 + i) + \$100 equal \$300. So Statement 1 is false.
- Statement 2 is false, since FW of Project C is \$150.

Therefore, the correct answer is (c).

5.20)

(a) From the project balance diagram, note that $\text{PW}(24\%)_1 = 0$ for project 1 and $\text{PW}(23\%)_2 = 0$ for project 2.

$$\begin{aligned}\text{PW}(24\%)_1 &= -\$100 + \$40(P/F,24\%,1) + \$80(P/F,24\%,2) \\ &\quad + X(P/F,24\%,3) \\ &= 0 \\ \text{PW}(23\%)_2 &= -\$100 + \$30(P/F,23\%,1) + Y(P/F,23\%,2) \\ &\quad + \$80(P/F,23\%,3) \\ &= 0\end{aligned}$$

Solving for X and Y yields $X = \$29.96$ and $Y = \$49.35$, respectively.

(b) Since $\text{PW}(24\%) = 0$, this implies that $\text{FW}(24\%) = \text{PB}(24\%)_3 = 0$.

(c)

$$\begin{aligned}a &= -100 + 30 + 49.35 + 80 = \$59.35 \\ b &= -100 + 40 + 80 + 29.96 = \$49.96 \\ c &= 17.91\%\end{aligned}$$

5.21)

(a) In Part (b), it is determined that *i*= 10%.

n	A_n	Project Balance
0	-\$1,000	-\$1,000
1	\$200	-\$900
2	\$490	-\$500
3	\$550	\$0

4	-$100	-$100
5	$200	$90

(b)

$$\text{PB}(i)_2 = -\$900(1+i)+\$490 = -\$500$$
$$i = 10\%$$
$$\text{PW}(10\%) = \$90(P/F,10\%,5) = \$55.88$$

5.22)

(a)

$$\begin{aligned}\text{FW}(15\%)_A &= -\$5,000(F/P,15\%,5)+\$500(F/P,15\%,4)\\ &\quad +\cdots-\$500\\ &= -\$4,691\\ \text{FW}(15\%)_B &= -\$5,000(F/P,15\%,5)+\$2,000(F/P,15\%,4)\\ &\quad +\cdots+\$3,500\\ &= \$4,741.10\\ \text{FW}(15\%)_C &= -\$5,000(F/P,15\%,5)+\$3,000(F/P,15\%,2)\\ &\quad +\cdots+\$13,000\\ &= \$14,960.71\\ \text{FW}(15\%)_D &= -\$5,000(F/P,15\%,5)+\$500(F/P,15\%,4)\\ &\quad +\cdots+\$1,250\\ &= \$3,676.97\\ \text{FW}(15\%)_E &= -\$5,000(F/P,15\%,3)+\$1,000(F/P,15\%,2)\\ &\quad +\cdots+\$2,000\\ &= -\$831.87\end{aligned}$$

(b),(c),(d)

Project A

n	Cash Flow	Cost of funds	Project Balance
0	-$5,000.0	$0	-$5,000
1	$500.0	-$750	-$5,250
2	$900.0	-$788	-$5,138
3	$1,000.0	-$771	-$4,908
4	$2,000.0	-$736	-$3,644
5	-$500.0	-$547	-$4,691

Discounted payback period for project A - none

Project B

n	Cash Flow	Cost of funds	Project Balance
0	-$5,000.0	$0	-$5,000
1	$2,000.0	-$750	-$3,750
2	-$3,000.0	-$563	-$7,313
3	$5,000.0	-$1,097	-$3,409
4	$5,000.0	-$511	$1,079
5	$3,500.0	$162	$4,741

Discounted payback period for project B – 4 years

Project C

n	Cash Flow	Cost of funds	Project Balance
0	-$5,000.0	$0	-$5,000
1	$0.0	-$750	-$5,750
2	$0.0	-$863	-$6,613
3	$3,000.0	-$992	-$4,604
4	$7,000.0	-$691	$1,705
5	$13,000.0	$256	$14,961

Discounted payback period for project C - 4years

Project D

n	Cash Flow	Cost of funds	Project Balance
0	-$5,000.0	$0	-$5,000
1	$500.0	-$750	-$5,250
2	$2,000.0	-$788	-$4,038
3	$3,000.0	-$606	-$1,643
4	$4,000.0	-$246	$2,110
5	$1,250.0	$317	$3,677

Discounted payback period for project D - 4years

Project E

n	Cash Flow	Cost of funds	Project Balance
0	-$5,000.0	$0	-$5,000
1	$1,000.0	-$750	-$4,750
2	$3,000.0	-$713	-$2,463
3	$2,000.0	-$369	-$832

Discounted payback period for project E - none

5.23)

(a)

$$\begin{aligned}\text{PW}(10\%)_A &= -\$100 + \$50(P/A,10\%,3)\\ &\quad -\$100(P/F,10\%,4)\\ &\quad +\$400(P/A,10\%,2)(P/F,10\%,4)\\ &= \$430.20\end{aligned}$$

$$\begin{aligned}\text{PW}(10\%)_B &= -\$100 + \$40(P/A,10\%,3)\\ &\quad +\$10(P/A,10\%,2)(P/F,10\%,3)\\ &= \$12.51\end{aligned}$$

$$\begin{aligned}\text{PW}(10\%)_C &= \$100 - \$40(P/A,10\%,3)\\ &= \$0.53\end{aligned}$$

All projects are acceptable.

(b)

$$\begin{aligned}\text{FW}(10\%)_A &= \$430.20(F/P,10\%,6)\\ &= \$762.13\end{aligned}$$

$$\begin{aligned}\text{FW}(10\%)_B &= \$12.51(F/P,10\%,5)\\ &= \$20.15\end{aligned}$$

$$\begin{aligned}\text{FW}(10\%)_C &= \$0.53(F/P,10\%,3)\\ &= \$0.70\end{aligned}$$

All projects are acceptable.

(c)

$$\begin{aligned}
\text{FW}(i)_A &= [-\$100(F/P,10\%,3)+\$50(F/A,10\%,3)](F/P,15\%,3) \\
&\quad +[-\$100(F/P,15\%,2)+\$400(F/A,15\%,2)] \\
&= \$777.08 \\
\text{FW}(i)_B &= [-\$100(F/P,10\%,3)+\$40(F/A,10\%,3)](F/P,15\%,3) \\
&\quad +\$10(F/P,15\%,2)+\$10(F/P,15\%,1) \\
&= \$23.66 \\
\text{FW}(i)_C &= \$100(F/P,10\%,3)(F/P,15\%,3) \\
&\quad -\$40(F/A,10\%,3)(F/P,15\%,3) \\
&= \$1.065
\end{aligned}$$

5.24)

(a)

$$\begin{aligned}
\text{PW}(0\%)_A &= 0 \\
\text{PW}(18\%)_B &= \$575(P/F,18\%,5) = \$251.34 \\
\text{PW}(12\%)_C &= 0
\end{aligned}$$

(b) Assume that $A_2 = \$500.$

$$\begin{aligned}
\text{PB}(12\%)_2 &= -\$530(1.12)+\$500 = X \\
X &= -\$93.60
\end{aligned}$$

.

(c) The net cash flows for each project are as follows:

Net Cash Flow			
n	A	B	C
0	-$1,000	-$1,000	-$1,000
1	$200	$500	$590
2	$200	$500	$500
3	$200	$300	-$106
4	$200	$300	$147
5	$200	$300	$100

Sample calculation for Project C:

$$\begin{aligned}
\text{PW}(12\%)_0 &= -\$1,000 \\
\text{PW}(12\%)_1 &= -\$1,000(1.12)+A_1 = \$530
\end{aligned}$$

Solving for A_1 yields A_1 = $590.

(d)

$$\text{FW}(0\%)_A = 0$$
$$\text{FW}(18\%)_B = \$575$$
$$\text{FW}(12\%)_C = 0$$

5.25)

(a)

$$\begin{aligned}\text{PW}(13\%) &= \$40,000(P/A,13\%,5)\\ &\quad +\$50,000(P/A,13\%,5)(P/F,13\%,5)\\ &\quad +(\$60,000/0.13)(P/F,13\%,10)\\ &= \$372,103.72\end{aligned}$$

(b)

$$\begin{aligned}\text{PW}(13\%) &= A/i\\ A &= \$372,103.72(0.13)\\ &= \$48,373.48\end{aligned}$$

5.26)

$$\text{PW}(12\%) = \$1,106$$
$$\text{CE}(12\%) = \frac{\$1,106(A/P,12\%,4)}{0.12} = \$3,034$$

5.27) Given: $r = 6\%$ compounded monthly, maintenance cost = \$25,000 per year

$$\begin{aligned}i_a &= (1+0.06/12)^{12} - 1\\ &= 6.17\%\\ \text{CE}(6.17\%) &= \$25,000/0.0617\\ &= \$405,186.39\end{aligned}$$

5.28) Given: Construction cost = \$10,000,000, renovation cost = \$1,000,000 every 10 years, annual $O\&M$ costs = \$100,000 and $i = 5\%$ per year

(a)

$$
\begin{aligned}
P_1 &= \$10,000,000 \\
P_2 &= \frac{\$1,000,000(A/F,5\%,10)}{0.05} \\
&= \$1,590,000 \\
P_3 &= \$100,000/0.05 \\
&= \$2,000,000 \\
\text{CE}(5\%) &= P_1 + P_2 + P_3 \\
&= \$13,590,000
\end{aligned}
$$

(b)

$$
\begin{aligned}
P_1 &= \$10,000,000 \\
P_2 &= \frac{\$1,000,000(A/F,5\%,15)}{0.05} \\
&= \$926,000 \\
P_3 &= \$100,000/0.05 \\
&= \$2,000,000 \\
\text{CE}(5\%) &= P_1 + P_2 + P_3 \\
&= \$12,926,000
\end{aligned}
$$

(c)

- 10-year cycle with 10% of interest:

$$
\begin{aligned}
P_1 &= \$10,000,000 \\
P_2 &= \frac{\$1,000,000(A/F,10\%,10)}{0.10} \\
&= \$627,000 \\
P_3 &= \$100,000/0.10 \\
&= \$1,000,000 \\
\text{CE}(10\%) &= \$11,627,000
\end{aligned}
$$

- 15-year cycle with 10% of interest:

$$P_1 = \$10,000,000$$
$$P_2 = \frac{\$1,000,000(A/F,10\%,15)}{0.10}$$
$$= \$315,000$$
$$P_3 = \$100,000/0.10$$
$$= \$1,000,000$$
$$\text{CE}(10\%) = \$11,315,000$$

As interest rate increases, *CE* value decreases.

5.29) Given: Cost to design and build $= \$650,000$, rework cost $= \$100,000$ every 10 years, new type of gear $= \$50,000$ at the end of 5th year, annual operating costs $= \$30,000$ for the first 15 years and $\$35,000$ thereafter

$$\text{CE}(8\%) = \$650,000 + \frac{\$100,000(A/F,8\%,10)}{0.08}$$
$$+\$50,000(P/F,8\%,5) + \$30,000(P/A,8\%,15)$$
$$+\frac{\$35,000}{0.08}(P/F,8\%,15)$$
$$= \$1,165,019$$

5.30)

(a)

$$\text{PW}(0.5\%) = \$2,160(P/A,0.5\%,240)$$
$$= \$301,494.47$$

(b)

$$\text{PW}(0.5\%) = \$2,160(P/A,0.5\%,480)$$
$$= \$392,574.78$$

(c)

$$\text{PW}(0.5\%) = \frac{A}{i}$$
$$A = \frac{\$2,160}{0.005}$$
$$= \$432,000$$

Comments: Longer life means greater total benefit, but most of the benefit is collected in the first 20 years.

5.31)

(a)

$$\text{PW}(25\%)_A = -\$1,000 + \$912(P/F, 25\%, 1) + \$684(P/F, 25\%, 2) + \$456(P/F, 25\%, 3) + \$228(P/F, 25\%, 4) = \$494.22$$

$$\text{PW}(25\%)_B = -\$1,000 + \$284(P/F, 25\%, 1) + \$568(P/F, 25\%, 2) + \$852(P/F, 25\%, 3) + \$1,136(P/F, 25\%, 4) = \$492.25$$

Select project A.

(b)

Project A

n	Cash Flow	Cost of funds	Project Balance
0	-$1000	$0	-$1,000
1	$912	-$250	-$338
2	$684	-$85	$262
3	$456	$65	$783
4	$228	196	$1,207

Project B

n	Cash Flow	Cost of funds	Project Balance
0	-$1,000	$0	-$1,000
1	$284	-$250	-$966
2	$568	-$242	-$640
3	$852	-$160	$53
4	$1,136	$13	$1,202

Project B is exposed to higher risk of loss if either project terminates at the end of the year 2, according to the results below.

5.32)

(a)

$$\begin{aligned}\text{PW}(12\%)_A &= -\$1,000,000 + \$700,000(P/A,12\%,2)\\ &= \$183,070\\ \text{PW}(12\%)_B &= -\$1,200,000 + \$700,000(P/F,12\%,1)\\ &\quad + \$1,000,000(P/F,12\%,2)\\ &= \$222,230\end{aligned}$$

Select project B.

(b)

$$\begin{aligned}\text{PW}(22\%)_A &= -\$1,000,000 + \$700,000(P/A,22\%,2)\\ &= \$44,074\\ \text{PW}(22\%)_B &= -\$1,200,000 + \$700,000(P/F,22\%,1)\\ &\quad + \$1,000,000(P/F,22\%,2)\\ &= \$45,633\end{aligned}$$

Select project B.

5.33)

(a)

$$\begin{aligned}\text{PW}(12\%)_A &= -\$5,000 + \$2,610(P/F,12\%,1)\\ &\quad + \$2,930(P/F,12\%,2) + \$2,300(P/F,12\%,3)\\ &= \$1,303.23\\ \text{PW}(12\%)_B &= -\$3,200 + \$1,210(P/F,12\%,1)\\ &\quad + \$1,720(P/F,12\%,2) + \$1,500(P/F,12\%,3)\\ &= \$319.2\end{aligned}$$

Select Project A.

(b)

$$\begin{aligned}\text{FW}(12\%)_A &= \$1,303.23(F/P,12\%,3)\\ &= \$1,830.94\\ \text{FW}(12\%)_B &= \$319.2(F/P,12\%,3)\\ &= \$448.44\end{aligned}$$

Select Project A.

5.34)

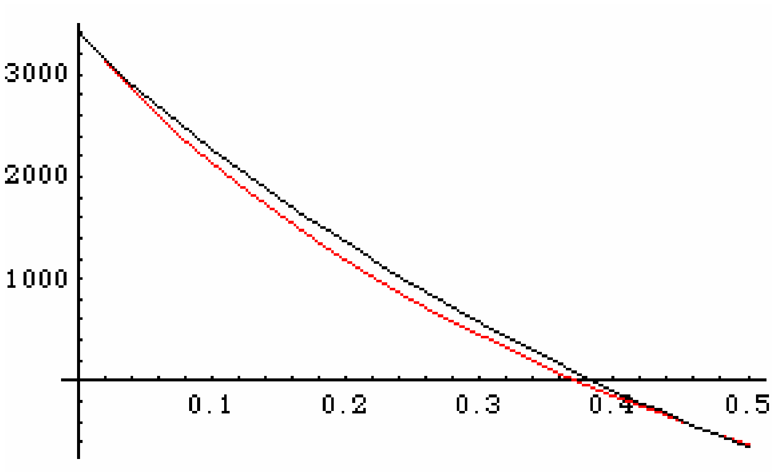
(a)

$$\text{PW}(15\%)_A = -\$4,000 + \$400(P/F, 15\%, 1) + \$7,000(P/F, 15\%, 2) = \$1,640.83$$

$$\text{PW}(15\%)_B = -\$8,500 + \$11,500(P/F, 15\%, 1) + \$400(P/F, 15\%, 2) = \$1,802.46$$

Select project B.

(b) Project B dominates Project A at any interest rate (0% to 46.7%.) as indicated in the following present worth profile. Note however that for very high interest rate (i > 46.7%), Project A is less undesirable than project B.



(X axis-interest rate, Y axis-PW(i))

5.35)

(a)

$$\text{PW}(15\%)_A = -\$15,000 + \$9,500(P/F, 15\%, 1) + \$12,500(P/F, 15\%, 2) + \$7,500(P/F, 15\%, 3) = \$7,644.03$$

(b)

$$\text{PW}(15\%)_B = -\$25,000 + X(P/A, 15\%, 2)(P/F, 15\%, 1) = \$9,300$$

$$X = \$24,262.57$$

(c) Note that the net future worth of the project is equivalent to its terminal project balance.

$$\text{PB}(15\%)_3 = \$7{,}643.7(F/P, 15\%, 3)$$
$$= \$11{,}625.30$$

(d) Select B, which has the greater PW.

5.36)

(a) Project balances as a function of time are as follows:

Project Balances		
n	A	D
0	-\$2,500	-\$5,000
1	-\$2,100	-\$6,000
2	-\$1,660	-\$7,100
3	-\$1,176	-\$3,810
4	-\$694	-\$1,191
5	-\$163	\$1,690
6	\$421	\$3,859
7	\$763	\$7,245
8	\$1,139	

All figures above are rounded to nearest dollars.

(b) Knowing the relationship $\text{FW}(i) = \text{PB}(i)_N$,

$$\text{FW}(10\%)_A = \$1{,}139$$
$$\text{FW}(10\%)_D = \$7{,}245$$

(c) Assuming a required service period of 8 years

$$\begin{aligned}\text{PW}(10\%)_B &= -\$7{,}000 - \$1{,}500(P/A, 10\%, 8) \\ &\quad -\$1{,}000(P/F, 10\%, 1) - \$500(P/F, 10\%, 2) \\ &\quad -\$1{,}500(P/F, 10\%, 7) - \$1{,}500(P/F, 10\%, 8) \\ &= -\$17{,}794\end{aligned}$$

$$\begin{aligned}\text{PW}(10\%)_C &= -\$5{,}000 - \$2{,}000(P/A, 10\%, 7) \\ &\quad -\$3{,}000(P/F, 10\%, 8) \\ &= -\$16{,}136\end{aligned}$$

Select Project C.

5.37) Given: Required service period $=$ infinite, analysis period $=$ least common multiple service periods (6 years)

- Model A:

$$\begin{aligned}\text{PW}(12\%)_{\text{cycle}} &= -\$11{,}000+\$7{,}500(P/F,12\%,1)\\ &\quad +\$8{,}000(P/F,12\%,2)+\$5{,}000(P/F,12\%,3)\\ &= \$5{,}633.35\\ \text{PW}(12\%)_{\text{total}} &= \$5{,}633.35[1+(P/F,12\%,3)]\\ &= \$9{,}643.11\end{aligned}$$

- Model B:

$$\begin{aligned}\text{PW}(12\%)_{\text{cycle}} &= -\$25{,}000+\$14{,}500(P/F,12\%,1)\\ &\quad +\$18{,}000(P/F,12\%,2)\\ &= \$2{,}296.65\\ \text{PW}(12\%)_{\text{total}} &= \$2{,}296.65[1+(P/F,12\%,2)\\ &\quad +(P/F,12\%,4)]\\ &= \$5{,}587.06\end{aligned}$$

Model A is preferred.

5.38)

(a) Without knowing the future replacement opportunities, we may assume that both alternatives will be available in the future with the same investment and expenses. We further assume that the required service period will be indefinite.

(b) With the common service period of 24 years,

- Project A:

$$\begin{aligned}\text{PW}(10\%)_{\text{cycle}} &= -\$900-\$400(P/A,10\%,3)\\ &\quad +\$200(P/F,10\%,3)\\ &= -\$1{,}744.48\\ \text{PW}(10\%)_{\text{total}} &= -\$1{,}744.48[1+(P/A,33.10\%,7)]\\ &= -\$6{,}302.63\end{aligned}$$

Note that the effective interest rate for a 3-year cycle is

$$(1.10)^3-1=33.10\%$$

- Project B:

$$\begin{aligned} PW(10\%)_{cycle} &= -\$1,800 - \$300(P/A,10\%,8) \\ &\quad +\$500(P/F,10\%,8) \\ &= -\$3,167.22 \\ PW(10\%)_{total} &= -\$3,167.22[1+(P/F,10\%,8) \\ &\quad +(P/F,10\%,16)] \\ &= -\$5,334.03 \end{aligned}$$

Project B is preferred.

(c)

$$\begin{aligned} PW(10\%)_A &= -\$1,744.48 \\ PW(10\%)_B &= -\$1,800 - \$300(P/A,10\%,3) + S(P/F,10\%,3) \\ &= -\$2,546.06 + 0.7513S \end{aligned}$$

Let $PW(10\%)_A = PW(10\%)_B$ and solve for S.

$$S = \$1,067$$

5.39)

(a) Assuming a common service period of 15 years

- Project A:

$$\begin{aligned} PW(12\%)_{cycle} &= -\$12,000 - \$2,000(P/A,12\%,5) \\ &\quad +\$2,000(P/F,12\%,5) \\ &= -\$18,075 \\ PW(12\%)_{total} &= -\$18,075[1+(P/A,76.23\%,2)] \\ &= -\$34,151 \end{aligned}$$

$$\text{Note}: (1.12)^5 - 1 = 76.23\%$$

- Project B:

$$\begin{aligned} PW(12\%)_{cycle} &= -\$10,000 - \$2,100(P/A,12\%,3) \\ &\quad +\$1,000(P/F,12\%,3) \\ &= -\$14,332 \\ PW(12\%)_{total} &= -\$14,332[1+(P/A,40.49\%,4)] \\ &= -\$40,642 \end{aligned}$$

$$\text{Note}: (1.12)^3 - 1 = 40.49\%$$

Select project A.

(b)

- Project A with 2 replacement cycles:

$$\begin{aligned} \text{PW}(12\%) &= -\$18,074 - \$18,074(P/F,12\%,5) \\ &= -\$28,329.67 \end{aligned}$$

- Project B with 4 replacement cycles where the 4th replacement cycle ends at the end of first operating year:

$$\begin{aligned} \text{PW}(12\%) &= -\$14,332[1+(P/F,12\%,3)+(P/F,12\%,6)] \\ &\quad -[\$10,000+(\$2,100-\$6,000)(P/F,12\%,1)] \\ &\quad \times(P/F,12\%,9) \\ &= -\$34,144.73 \end{aligned}$$

Project A is still a better choice.

5.40)

- Method A:

$$\begin{aligned} \text{CE}(12\%)_A &= \$30,000 + \frac{\$10,000(A/F,12\%,5)}{0.12} \\ &= \$30,000 + \$13,117.50 \\ &= \$43,117.5 \end{aligned}$$

- Method B:

$$\begin{aligned} \text{CE}(12\%)_B &= \$75,000 + \frac{\$90,000(A/F,12\%,50)}{0.12} \\ &= \$75,000 + \$312.50 \\ &= \$75,312.5 \end{aligned}$$

Since $\text{CE}(12\%)$ values above represent cost, project A is preferred.

5.41)

- Standard Lease Option:

$$\begin{aligned} \text{PW}(0.5\%)_{\text{SL}} &= -\$5,500 - \$1,150(P/A,0.5\%,24) \\ &\quad +\$1,000(P/F,0.5\%,24) \\ &= -\$30,560.10 \end{aligned}$$

- Single Up-Front Option:

$$\begin{aligned} \text{PW}(0.5\%)_{\text{SU}} &= -\$31,500 + \$1,000(P/F,0.5\%,24) \\ &= -\$30,612.82 \end{aligned}$$

Select the standard lease option, as you will save \$52.72 in present worth.

5.42)

- Machine A:

$$\begin{aligned}\text{PW}(13\%) &= -\$75,200 - (\$6,800 + \$2,400)(P/A, 13\%, 6) \\ &\quad + \$21,000(P/F, 13\%, 6) \\ &= -\$101,891\end{aligned}$$

- Machine B:

$$\begin{aligned}\text{PW}(13\%) &= -\$44,000 - \$11,500(P/A, 13\%, 6) \\ &= -\$89,971\end{aligned}$$

Machine B is a better choice.

5.43)

(a)

- Required HP to produce 10 HP:

Motor A:

$$X_1 = 10/0.85 = 11.765 \text{ HP}$$

Motor B:

$$X_2 = 10/0.90 = 11.111 \text{ HP}$$

- Annual energy cost:

Motor A:

$$11.765(0.7457)(1,500)(0.07) = \$921.18$$

Motor B:

$$11.111(0.7457)(1,500)(0.07) = \$869.97$$

- Equivalent cost:

$$\begin{aligned}PW(8\%)_A &= -\$800 - \$921.18(P/A, 8\%, 15) \\ &\quad + \$50(P/F, 8\%, 15) \\ &= -\$8,669\end{aligned}$$

$$\begin{aligned}PW(8\%)_B &= -\$1,200 - \$869.97(P/A, 8\%, 15) \\ &\quad + \$100(P/F, 8\%, 15) \\ &= -\$8,614\end{aligned}$$

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Note: Power bill is paid at years end, not monthly.
Motor B is preferred.

(b) With 2,500 operating hours:

$$\begin{aligned}\text{PW}(8\%)_A &= -\$800 - \$1,535.3(P/A, 8\%, 15)\\ &\quad +\$50(P/F, 8\%, 15)\\ &= -\$13,925\\ \text{PW}(8\%)_B &= -\$1,200 - \$1,449.96(P/A, 8\%, 15)\\ &\quad +\$100(P/F, 8\%, 15)\\ &= -\$13,579\end{aligned}$$

Motor B is still preferred.

5.44) Since only Model B is repeated in the future, we may have the following sequence of replacement cycles:

- Option 1: Purchase Model A now and repeat Model A forever.
- Option 2: Purchase Model B now and replace it at the end of year 2 by Model A. Then repeat Model A forever.

$$\begin{aligned}\text{PW}(15\%)_A &= -\$6,600 + \$3,500(P/A, 15\%, 3)\\ &\quad +\$1,000(P/F, 15\%, 2) + \$2,000(P/F, 15\%, 3)\\ &= \$3,462.3\\ \text{AE}(15\%)_A &= \$3,462.3(A/P, 15\%, 3)\\ &= \$1,516.49\\ \text{PW}(15\%)_B &= -\$16,500 + \$11,000(P/F, 15\%, 1) + \$12,000(P/F, 15\%, 2)\\ &= \$2,138.94\\ \text{AE}(15\%)_B &= \$2,138.94(A/P, 15\%, 2)\\ &= \$1,315.7\end{aligned}$$

(a)

- Option 1:

$$\begin{aligned}\text{PW}(15\%)_{AAA\cdots} &= \frac{A}{i} = \frac{\$1,516.49}{0.15}\\ &= \$10,109.93\end{aligned}$$

- Option 2:

$$\begin{aligned}\text{PW}(15\%)_{BAA\cdots} &= \$2{,}138.94 + \frac{\$1{,}516.49}{0.15}(P/F,15\%,2)\\ &= \$8{,}901.21\end{aligned}$$

Option 1 is a better choice.

(b) Let S be the salvage value of Model A at the end of year 2.

$$-\$6{,}600 + \$3{,}500(P/F,15\%,1) + (\$4{,}500 + S)(P/F,15\%,2) = \$2{,}138.94$$

Solving for S yields

$$S = \$3{,}032.25$$

5.45)

- Since either tower will have no salvage value after 20 years, we may select the analysis period of 35 years:

$$\begin{aligned}\text{PW}(11\%)_{\text{Bid A}} &= -\$80{,}000 - \$1{,}000(P/A,11\%,35)\\ &= -\$88{,}855\\ \text{PW}(11\%)_{\text{Bid B}} &= -\$78{,}000 - \$1{,}750(P/A,11\%,35)\\ &= -\$93{,}497\end{aligned}$$

Bid A is a better choice.

- If we assume an infinite analysis period, the present worth of each bid will be

$$\begin{aligned}\text{PW}(11\%)_{\text{Bid A}} &= \frac{[-\$80{,}000 - \$1{,}000(P/A,11\%,40)](A/P,11\%,40)}{0.11}\\ &= -\$90{,}341\\ \text{PW}(11\%)_{\text{Bid B}} &= \frac{-\$93{,}497(A/P,11\%,35)}{0.11}\\ &= -\$95{,}985\end{aligned}$$

Bid A is still preferred.

5.46)

- Option 1: Non-deferred Plan (install remaining 7 units)

$$\begin{aligned}\text{PW}(12\%)_1 &= -\$200{,}000 - \$21{,}000(P/A,12\%,8)\\ &= -\$304{,}320\end{aligned}$$

- Option 2: Deferred Plan

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$$\begin{aligned}\text{PW}(12\%)_2 = &-\$100,000(P/F,12\%,2)\\ &-\$6,000(P/A,12\%,3)(P/F,12\%,2)\\ &-\$160,000(P/F,12\%,5)\\ &-\$15,000(P/A,12\%,3)(P/F,12\%,5)\\ &-\$140,000(P/F,12\%,8)\\ =&-\$258,982\end{aligned}$$

Option 2 is a better choice.

5.47)

- Alternative A: Once-for-all expansion

$$\begin{aligned}\text{PW}(15\%)_A = &-\$30M - \$0.40M(P/A,15\%,25)\\ &+\$0.85M(P/F,15\%,25)\\ =&-\$32,559,839\end{aligned}$$

- Alternative B: Incremental expansion

$$\begin{aligned}\text{PW}(15\%)_B = &-\$10M - \$18M(P/F,15\%,10)\\ &-\$12M(P/F,15\%,15)+\$1.5M(P/F,15\%,25)\\ &-\$0.25M(P/A,15\%,25)\\ &-\$0.10M(P/A,15\%,15)(P/F,15\%,10)\\ &-\$0.10M(P/A,15\%,10)(P/F,15\%,15)\\ =&-\$17,700,745\end{aligned}$$

Select alternative B.

5.48)

- **Option 1**: Tank/tower installation

  $PW(12\%)_1 = -\$164,000$

- **Option 2**: Tank/hill installation with the pumping equipment replaced at the end of 20 years at the same cost

$$\begin{aligned}\text{PW}(12\%) = &-(\$120,000+\$12,000)\\ &-(\$12,000-\$1,000)(P/F,12\%,20)\\ &+\$1,000(P/F,12\%,40)-\$1,000(P/A,12\%,40)\\ =&-\$141,374\end{aligned}$$

Option 2 is a better choice.

5.49)

- **Option 1**: Process device A lasts only 4 years. You have a required service period of 6 years. If you take this option, you must consider how you will satisfy the rest of the required service period at the end of the project life. One option would subcontract the remaining work for the duration of the required service period. If you select this subcontracting option along with the device A, the equivalent net present worth would be

$$\begin{aligned}\text{PW}(12\%)_1 &= -\$100{,}000 - \$60{,}000(P/A, 12\%, 4)\\ &\quad +\$10{,}000(P/F, 12\%, 4)\\ &\quad -\$100{,}000(P/A, 12\%, 2)(P/F, 12\%, 4)\\ &= -\$383{,}292\end{aligned}$$

- **Option 2**: This option creates no problem because its service life coincides with the required service period.

$$\begin{aligned}\text{PW}(12\%)_2 &= -\$150{,}000 - \$50{,}000(P/A, 12\%, 6)\\ &\quad +\$30{,}000(P/F, 12\%, 6)\\ &= -\$340{,}371\end{aligned}$$

- **Option 3**: With the assumption that the subcontracting option would be available over the next 6 years at the same cost, the equivalent present worth would be

$$\begin{aligned}\text{PW}(12\%)_3 &= -\$100{,}000(P/A, 12\%, 6)\\ &= -\$411{,}141\end{aligned}$$

With the restricted assumptions above, option 2 appears to be best alternative.