# Chapter 2: Time Value of Money

2.1) $I = iPN = (0.09)(\$3,000)(5) = \$1,350$

2.2)

- Simple interest:

$$\begin{aligned} F &= P(1+iN) \\ \$4,000 &= \$2,000(1+0.08N) \\ N &= 12.5 \text{ years (or 13 years)} \end{aligned}$$

- Compound interest:

$$\begin{aligned} \$4,000 &= \$2,000(1+0.07)^N \\ 2 &= 1.07^N \\ \log 2 &= N \log 1.07 \\ N &= 10.24 \text{ years (or 11 years)} \end{aligned}$$

2.3)

- Simple interest:

$$\begin{aligned} I &= iPN = (0.07)(\$10,000)(20) \\ &= \$14,000 \end{aligned}$$

- Compound interest:

$$\begin{aligned} I &= P\left[(1+i)^N - 1\right] = \$10,000\left[(1.07)^{20} - 1\right] \\ &= \$28,696.84 \end{aligned}$$

2.4)

- Compound interest:

$$\begin{aligned} F &= \$1,000(1+0.06)^5 \\ &= \$1,338.23 \end{aligned}$$

- Simple interest:

$$\begin{aligned} F &= \$1,000(1+0.07(5)) \\ &= \$1,350 \end{aligned}$$

The simple interest option is better.

2.5)

- Loan balance calculation:

| End of period | Principal Payment | Interest Payment | Remaining Balance |
|---|---|---|---|
| 0 | $0.00 | $0.00 | $5,000.00 |
| 1 | $835.46 | $450.00 | $4,164.54 |
| 2 | $910.65 | $374.81 | $3,253.89 |
| 3 | $992.61 | $292.85 | $2,261.28 |
| 4 | $1,081.94 | $203.52 | $1,179.33 |
| 5 | $1,179.32 | $106.14 | $0.00 |

2.6) $P = \$8,000(P/F,8\%,5) = \$8,000(0.6806) = \$5,444.8$

2.7) $F = \$20,000(F/P,10\%,2) = \$20,000(1.21) = \$24,200$

2.8)

- Alternative 1

$$P = \$100$$

- Alternative 2

$$P = \$120(P/F,8\%,2) = \$120(0.8573) = \$102.88$$

- Alternative 2 is preferred

2.9) (a) $F = \$7,000(F/P,9\%,8) = \$7,000(1.9926) = \$13,948.2$

(b) $F = \$1,250(F/P,4\%,12) = \$1,250(1.6010) = \$2,001.25$

(c) $F = \$5,000(F/P,7\%,31) = \$5,000(8.1451) = \$40,725.5$

(d) $F = \$20,000(F/P,6\%,7) = \$20,000(1.5036) = \$30,072$

2.10) (a) $P = \$4,500(P/F,7\%,6) = \$4,500(0.6663) = \$2,998.35$

(b) $P = \$6,000(P/F,8\%,15) = \$6,000(0.3152) = \$1,891.2$

(c) $P = \$20,000(P/F,9\%,5) = \$20,000(0.6499) = \$12,998$

(d) $P = \$12,000(P/F,10\%,8) = \$12,000(0.4665) = \$5,598$

2.11) (a) $P = \$6,000(P/F, 8\%, 5) = \$6,000(0.6806) = \$4,083.6$

(b) $F = \$15,000(F/P, 8\%, 4) = \$15,000(1.3605) = \$20,407.5$

2.12)

$$F = 3P = P(1+0.07)^N$$
$$\log 3 = N \log 1.07$$
$$N = 16.24 \text{ years (or 17 years)}$$

2.13)

$$F = 2P = P(1+0.12)^N$$

- $\log 2 = N \log 1.12$

  $N = 6.12$ years

- Rule of 72:

  $72/12 = 6$ years

2.14)

$$\begin{aligned} P &= \$35,000(P/F, 9\%, 4) + \$10,000(P/F, 9\%, 2) \\ &= \$35,000(0.7084) + \$10,000(0.8417) \\ &= \$33,211 \end{aligned}$$

2.15)

- Simple interest:

  $I = iPN = (0.1)(\$1,000)(3) = \$300$

- Compound interest:

  $$\begin{aligned} I &= P\left[(1+i)^N - 1\right] = \$1,000\left[(1+.095)^3 - 1\right] \\ &= \$312.93 \end{aligned}$$

- Susan's balance will be greater by \$12.93.

2.16) $P = \dfrac{\$3,000}{1.06^2} + \dfrac{\$3,500}{1.06^3} + \dfrac{\$4,000}{1.06^4} + \dfrac{\$6,000}{1.06^5} = \$13,260.58$

2.17)

$$\begin{aligned} F &= \$1,000(F/P, 8\%, 10) + \$1,500(F/P, 8\%, 8) \\ &\quad + \$2,000(F/P, 8\%, 6) \\ &= \$8,109.05 \end{aligned}$$

2.18)

$$
\begin{aligned}
P &= \$3,000,000 + \$2,400,000(P/A, 8\%, 5) \\
&\quad + \$3,000,000(P/A, 8\%, 5)(P/F, 8\%, 5) \\
&= \$20,734,774.86
\end{aligned}
$$

2.19)

$$
\begin{aligned}
P &= \$3,000(P/F, 9\%, 2) + \$4,000(P/F, 9\%, 5) \\
&\quad + \$5,000(P/F, 9\%, 7) \\
&= \$7,859.7
\end{aligned}
$$

2.20)

- Method 1:

$$
\begin{aligned}
F &= \$2,000(1.05)(1.1)(1.15) + \$3,000(1.1)(1.15) + \$5,000 \\
&= \$11,451.5
\end{aligned}
$$

- Method 2:

$$
\begin{aligned}
F &= \overbrace{\underbrace{(\$2,000(1.05) + \$3,000)}_{\$5,100}(1.10)(1.15)}^{\$6,451.50} + \$5,000 \\
&= \$11,451.50
\end{aligned}
$$

2.21)

$$
\begin{aligned}
\$150,000 &= \$20,000(P/A, 9\%, 5) - \$10,000(P/F, 9\%, 3) + X(P/F, 9\%, 6) \\
X &= \$134,046.98
\end{aligned}
$$

2.22)

$$
\begin{aligned}
F &= \$80,000 = \$10,000(1.08)^5 + \$12,000(1.08)^3 + X(1.08)^2 \\
X &= \$43,029.99
\end{aligned}
$$

2.23)

$$
\begin{aligned}
100(1.08)^4 &= 8(1.08)^3 + 9(1.08)^2 + 10(1.08) + 11 + X \\
X &= \$93.67
\end{aligned}
$$

This is the minimum selling price. So if John can sell the stock for a higher price than \$93.67, his return on investment will be higher than 8%.

2.24) (a) $F = \$3,000(F/A, 7\%, 8) = \$3,000(10.2598) = \$30,779.4$

(b) $F = \$3,000(F/A, 7\%, 8)(1.07) = \$32,933.96$

2.25) (a) $F = \$5,000(F/A,6\%,6) = \$5,000(6.9753) = \$34,876.5$

(b) $F = \$9,000(F/A,7.25\%,9) = \$108,928.76$

(c) $F = \$12,000(F/A,8\%,25) = \$12,000(73.1059) = \$877,270.8$

(d) $F = \$6,000(F/A,9.75\%,10) = \$94,485.71$

2.26) (a) $A = \$15,000(A/F,5\%,13) = \$15,000(0.0565) = \$847.5$

(b) $A = \$20,000(A/F,6\%,8) = \$20,000(0.1010) = \$2,020$

(c) $A = \$5,000(A/F,8\%,25) = \$5,000(0.0137) = \$68.5$

(d) $A = \$4,000(A/F,6.85\%,8) = \$391.98$

2.27)

$$\$35,000 = \$3,000(F/A,6\%,N)$$
$$(F/A,6\%,N) = 11.6666$$
$$\frac{(1+0.06)^N - 1}{0.06} = 11.6666$$
$$N \cdot \log(1.06) = \log(1.7)$$

$$N = 9.11 \text{ years}$$

2.28)

$$\$10,000 = A(F/A,7\%,5)$$
$$A = \$1,738.92$$

2.29)

$$\begin{aligned} F &= \$500(1.1)^{10} + \$1,000(1.1)^8 + \$1,000(1.1)^6 \\ &\quad + \$1,000(1.1)^4 + \$1,000(1.1)^2 + \$1,000 \\ &= \$8,886.12 \end{aligned}$$

2.30) (a) $A = \$15,000(A/P,8\%,5) = \$15,000(0.2505) = \$3,757.5$

(b) $A = \$3,500(A/P,9.5\%,4) = \$1,092.22$

(c) $A = \$8,000(A/P,11\%,3) = \$8,000(0.4092) = \$3,273.6$

(d) $A = \$25,000(A/P,6\%,20) = \$25,000(0.0872) = \$2,180$

2.31)

- Equal annual payment amount:

$$A = \$20,000(A/P,10\%,3) = \$20,000(0.4021) = \$8,042$$

- Loan balance calculation:

| End of period | Principal Payment | Interest Payment | Remaining Balance |
|---|---|---|---|
| 0 | $0.00 | $0.00 | $20,000.00 |
| 1 | $6,042.00 | $2,000.00 | $13,958.00 |
| 2 | $6,646.20 | $1,395.80 | $7,311.80 |
| 3 | $7,310.82 | $731.18 | $0 |

Interest payment for the second year = $1,395.80

2.32) (a) $P = \$5{,}000(P/A, 6\%, 8) = \$5{,}000(6.2098) = \$31{,}049$

(b) $P = \$7{,}500(P/A, 9\%, 10) = \$7{,}500(6.4177) = \$48{,}132.75$

(c) $P = \$1{,}500(P/A, 7.25\%, 6) = \$7{,}094.96$

(d) $P = \$9{,}000(P/A, 8.75\%, 30) = \$94{,}551.83$

2.33) (a) $$(A/P, 6.25\%, 36) = \frac{0.0625(1+0.0625)^{36}}{(1+0.0625)^{36}-1} = 0.07044$$

(b) $$(P/A, 9.25\%, 125) = \frac{(1+0.0925)^{125}-1}{0.0925(1+0.0925)^{125}} = 10.81064$$

2.34) $F = \$400(F/A, 9\%, 15)(1.09) = \$400(29.3609)(1.09) = \$12{,}801.35$

2.35)

$$\begin{aligned}
F &= F_1 + F_2 \\
&= \$5{,}000(F/A, 8\%, 5) + \$2{,}000(F/G, 8\%, 5) \\
&= \$5{,}000(F/A, 8\%, 5) + \$2{,}000(A/G, 8\%, 5)(F/A, 8\%, 5) \\
&= \$5{,}000(5.8666) + \$2{,}000(1.8465)(5.8666) \\
&= \$50{,}998.35
\end{aligned}$$

2.36)

$$\begin{aligned}
F &= \$1{,}200(F/A, 9\%, 5) - \$200(F/G, 9\%, 5) \\
&= \$1{,}200(F/A, 9\%, 5) - \$200(P/G, 9\%, 5)(F/P, 9\%, 5) \\
&= \$1{,}200(5.9847) - \$200(7.1110)(1.5386) \\
&= \$4{,}993.44
\end{aligned}$$

2.37)

$$
\begin{aligned}
P &= \$100(P/F,8\%,1) + \$150(P/F,8\%,3) \\
&\quad + \$200(P/F,8\%,5) + \$250(P/F,8\%,7) \\
&\quad + \$300(P/F,8\%,9) + \$350(P/F,8\%,11) \\
&= \$793.83
\end{aligned}
$$

2.38)

$$
\begin{aligned}
A &= \$15{,}000 - \$3{,}000(A/G,9\%,10) \\
&= \$15{,}000 - \$3{,}000(3.7978) \\
&= \$3{,}606.6
\end{aligned}
$$

2.39)

$$
\begin{aligned}
P &= \$1{,}000(P/A,9\%,8) + \$250(P/G,9\%,8) \\
&= \$1{,}000(5.5348) + \$250(16.8877) \\
&= \$9{,}756.73
\end{aligned}
$$

2.40)

$$
\begin{aligned}
C(P/G,12\%,6) &= \$800(F/A,12\%,4) \\
&\quad + [\$1{,}000 - \$200(P/G,12\%,4)](F/P,12\%,4) \\
C(8.9302) &= \$800(4.7793) \\
&\quad + [\$1{,}000 - \$200(4.1273)](1.5735)
\end{aligned}
$$

$$C = \$458.90$$

2.41) (a)

$$
\begin{aligned}
P &= \$3{,}000{,}000(P/A_1, -10\%, 12\%, 7) \\
&= \$3{,}000{,}000 \cdot \frac{1-(1-0.1)^7(1+0.12)^{-7}}{0.12-(-0.1)} \\
&= \$10{,}686{,}037.81
\end{aligned}
$$

(b) Note that the oil price increases at the annual rate of 5% while the oil production decreases at the annual rate of 10%. Therefore, the annual revenue can be expressed as follows:

$$
\begin{aligned}
A_n &= \$30(1+0.05)^{n-1}100{,}000(1-0.10)^{n-1} \\
&= \$3{,}000{,}000(0.945)^{n-1} \\
&= \$3{,}000{,}000(1-0.055)^{n-1}
\end{aligned}
$$

This revenue series is equivalent to a decreasing geometric gradient series with $g$ = -5.5%.

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| $N$ | $A_n$ |
|---|---|
| 1 | \$3,000,000 |
| 2 | \$2,835,000 |
| 3 | \$2,679,075 |
| 4 | \$2,531,726 |
| 5 | \$2,392,481 |
| 6 | \$2,260,894 |
| 7 | \$2,136,545 |

$$\begin{aligned} P &= \$3,000,000(P/A_{1,}\,-5.5\%,12\%,7) \\ &= \$3,000,000 \cdot \frac{1-(1-0.055)^{7}(1+0.12)^{-7}}{0.12-(-0.055)} \\ &= \$11,923,948.35 \end{aligned}$$

(c) Computing the present worth of the remaining series $(A_4, A_5, A_6, A_7)$ at the end of period 3 gives

$$\begin{aligned} P &= \$2,531,730(P/A_1,-5.5\%,12\%,4) \\ &= \$2,531,730 \cdot \frac{1-(1-0.055)^{4}(1+0.12)^{-4}}{0.12-(-0.055)} \\ &= \$7,134,825.54 \end{aligned}$$

2.42)

$$\begin{aligned} P &= \sum_{n=1}^{20} A_n (1+i)^{-n} \\ &= \sum_{n=1}^{20} (2{,}000{,}000) n (1.06)^{n-1} (1.06)^{-n} \\ &= (2{,}000{,}000/1.06) \sum_{n=1}^{20} n \left(\frac{1.06}{1.06}\right)^{n} \\ &= (2{,}000{,}000/1.06) \sum_{n=1}^{20} n \\ &= (2{,}000{,}000/1.06) \frac{20(21)}{2} \\ &= \$396,226,415.1 \end{aligned}$$

2.43) (a) The withdrawal series would be:

| Period | Withdrawal |
|---|---|
| 11 | $3,000 |
| 12 | $3,000(1.06) |
| 13 | $3,000(1.06)^2$ |
| 14 | $3,000(1.06)^3$ |
| 15 | $3,000(1.06)^4$ |

Equivalent worth of the withdrawal series at period 10, using $i = 8\%$:

$$
\begin{aligned}
P &= \$3{,}000(P/A_1,6\%,8\%,5) \\
&= \$3{,}000 \cdot \frac{1-(1+0.06)^5(1+0.08)^{-5}}{0.08-(0.06)} \\
&= \$13{,}383.92
\end{aligned}
$$

Assuming that each deposit is made at the end of each year,
the following equivalence must be hold:

$$
\begin{aligned}
\$13{,}384 &= A(F/A,8\%,10) \\
&= 14.4866A \\
A &= \$923.88
\end{aligned}
$$

(b) Equivalent present worth of the withdrawal series at 6%

$$
P = \$3{,}000(P/A_1,6\%,6\%,5) = \$3{,}000\frac{5}{1+0.06} = \$14{,}150.94
$$

$$
\begin{aligned}
\$14{,}151 &= A(F/A,6\%,10) \\
&= 13.1808A \\
A &= \$1{,}073.60
\end{aligned}
$$

2.44)

$$
\begin{aligned}
P &= [\$100(F/A,10\%,8) + \$50(F/A,10\%,6) \\
&\quad + \$50(F/A,10\%,4)](P/F,10\%,8) \\
&= [\$100(11.4359) + \$50(7.7156) \\
&\quad + \$50(4.6410)](0.4665) \\
&= \$821.70
\end{aligned}
$$

2.45) Select (a).

2.46)

$$
\begin{aligned}
P(1.1)+\$500 &= \$300(P/F,10\%,2) \\
&\quad +\$300(P/F,10\%,3)+\$800(P/F,10\%,4) \\
&= \$300(0.8264) \\
&\quad +\$300(0.7513)+\$800(0.6830) \\
P &= \$472.46
\end{aligned}
$$

2.47)

Computing the equivalent worth at period 3 will require only two different types of interest factors.

$$
\begin{aligned}
V_{1,3} &= \$120(P/A,10\%,5)(F/P,10\%,3) \\
&= \$120(3.7908)(1.3310) \\
&= \$605.466 \\
V_{2,3} &= A(P/A,10\%,2)(F/P,10\%,3)+A(P/A,10\%,2) \\
&= A(1.7355)(1.3310)+A(1.7355) \\
&= 4.04545A \\
A &= \$605.466/4.04545 \\
&= \$149.67
\end{aligned}
$$

2.48)

$$
\begin{aligned}
P_{1,1} &= \$200(P/A,10\%,4)-100(P/A,10\%,2) \\
&= \$200(3.1699)-100(1.7355) \\
&= 460.43
\end{aligned}
$$

$$
\begin{aligned}
P_{2,1} &= X+X(P/A,10\%,4) \\
&= X+X(3.1699) \\
&= 4.1699X
\end{aligned}
$$

$$
\begin{aligned}
P_{1,1} &= P_{2,1} \\
\$460.43 &= 4.1699X \\
X &= \$110.42
\end{aligned}
$$

2.49)

$$P_1 = \$50(P/A,10\%,4) + \$35(P/A,10\%,2)(P/F,10\%,2)$$
$$= \$50(3.1699) + \$35(1.7355)(0.8264)$$
$$= 208.6926$$
$$P_2 = C(P/A,10\%,4) + C(P/A,10\%,2)(P/F,10\%,1)$$
$$= C(3.1699) + C(1.7355)(0.9091)$$
$$= 4.7476C$$

$$P_1 = P_2$$
$$C = \$43.96$$

2.50)

$$C(F/A,9\%,8) = \$5{,}000(P/A,9\%,2)$$
$$C(11.0285) = \$5{,}000(1.7591)$$
$$C = \$797.52$$

2.51) The original cash flow series is

| $n$ | $A_n$ |
|---|---|
| 0 | \$0 |
| 1 | \$800 |
| 2 | \$820 |
| 3 | \$840 |
| 4 | \$860 |
| 5 | \$880 |
| 6 | \$900 |
| 7 | \$920 |
| 8 | \$300 |
| 9 | \$300 |
| 10 | \$300 - \$500 |

2.52)

$$2C + C(P/A,12\%,7)(P/F,12\%,1)$$
$$= \$1{,}200(P/A,12\%,8) - 400(P/A,12\%,4)$$

$$2C + C(4.5638)(0.8929)$$
$$= \$1{,}200(4.9676) - 400(3.0373)$$

$$6.075C = \$4,746.20$$
$$C = \$781.27$$

2.53)

$$200(1.06)(1.08)(1.12)(1.15)$$
$$+ X(1.08)(1.12)(1.15)$$
$$+ \$300(1.15)$$
$$= \$1000$$

$$247.9 + 1.39104X + 345 = 1000$$
$$1.39104X = 360.1$$
$$X = \$258.87$$

2.54) Computing the equivalent worth at $n = 5$,

$$X = \$5,000(F/A,10\%,5) + \$5,000(P/A,10\%,5)$$
$$= \$5,000(6.1051) + \$5,000(3.7908)$$
$$= \$49,475.5$$

2.55)

$$A(F/A,8\%,18) = \$20,000 + \$20,000(P/A,8\%,3)$$
$$A(37.4502) = \$20,000 + \$20,000(2.5771)$$
$$= \$71542$$

$$A = \$1910.32$$

2.56)

$$P_{1,0} = \$500 + \$500(P/A,10\%,5)$$
$$= \$500 + \$500(3.7908)$$
$$= \$2,395.4$$

$$P_{2,0} = X\left[(P/F,10\%,1) + (P/F,10\%,4)\right]$$
$$= X\left[(0.9091) + (0.6830)\right]$$
$$= 1.5921X$$

$$X = \$1,504.55$$

2.57)

$$P_{1,2} = X(P/F,8\%,3)$$
$$= X(0.7938)$$

$$P_{2,2} = 800(P/A,8\%,10)$$
$$= 800(6.7101)$$
$$= 5368.08$$

$$X = 6,762.51$$

2.58)

$$C(P/A,9\%,5)(P/F,9\%,1) = \$4,000$$
$$C(3.8897)(0.9174) = \$4,000$$
$$C = \$1,120.95$$

2.59)

$$P(1.05)(1.08)(1.1)(1.06)$$
$$= \$1,000(1.08)(1.1)(1.06) + \$1,500(1.1)(1.06)$$
$$+\$1,000(1.06) + \$1000$$
$$P(1.322244) = \$5,068.28$$
$$P = \$3,833.09$$

2.60)

- Exact:

$$2P = P(1+i)^5$$
$$2 = (1+i)^5$$
$$\log 2 = 5\ \log(1+i)$$
$$i = 14.87\%$$

- Rule of 72:

$$72 / i = 5\text{years}$$
$$i = 14.4\%$$

2.61)

$$P_1 = \$150(P/A,i,5) - \$50(P/F,i,1)$$

- $$= \$150\left(\frac{(1+i)^5 - 1}{i(1+i)^5}\right) - \$50 \cdot (1+i)^{-1}$$

- $P_2 = \frac{\$200}{(1+i)} + \frac{\$150}{(1+i)^2} + \frac{\$50}{(1+i)^3} + \frac{\$200}{(1+i)^4} + \frac{\$50}{(1+i)^5}$
- $P_1 = P_2$ and solving $i$ with Excel Goal Seek function,
  $i = 14.96\%$

2.62)

$$\begin{aligned}\$35{,}000 &= \$10{,}000(F/P,i,5)\\ &= \$10{,}000(1+i)^5\\ i &= 28.47\%\end{aligned}$$

2.63) The equivalent future worth of the prize payment series at the end of Year 20 (or beginning of Year 21) is

$$\begin{aligned}F_1 &= \$1{,}952{,}381(F/A,6\%,20)\\ &= \$1{,}952{,}381(36.7856)\\ &= \$71{,}819{,}506.51\end{aligned}$$

The equivalent future worth of the lottery receipts is

$$\begin{aligned}F_2 &= (\$36{,}100{,}000 - \$1{,}952{,}381)(F/P,6\%,20)\\ &= (\$36{,}100{,}000 - \$1{,}952{,}381)(3.2071)\\ &= \$109{,}514{,}828.9\end{aligned}$$

The resulting surplus at the end of Year 20 is

$$\begin{aligned}F_2 - F_1 &= \$109{,}514{,}828.9 - \$71{,}819{,}506.51\\ &= \$37{,}695{,}322.4\end{aligned}$$

2.64)

$$\begin{aligned}&\$1{,}000(F/P,9.4\%,5) + \$500(F/A,9.4\%,5)\\ &= \$1{,}000((1+0.094)^5) + \$500(\frac{(1+0.094)^5 - 1}{0.094})\\ &= \$1{,}000(1.5671) + \$500(6.0326)\\ &= \$4{,}583.4\end{aligned}$$

$$\begin{aligned}&\$4{,}583.4(F/P,9.4\%,60)\\ &= \$4{,}583.4((1+0.094)^{60})\\ &= \$4{,}583.4(219.3)\\ &= \$1{,}005{,}141.21\end{aligned}$$

The main question is whether or not the U.S. government will be able to invest the social security deposits at 9.4% interest over 60 years.

2.65)

$$\begin{aligned}
P_{\text{Contract}} &= \$3,875,000 + \$3,125,000(P/F, 6\%, 1) \\
&\quad + \$5,525,000(P/F, 6\%, 2) + \cdots \\
&\quad + \$8,875,000(P/F, 6\%, 7) \\
&= \$3,875,000 + \$2,550,000(0.9434) \\
&\quad + \$5,525,000(0.8900) + \cdots \\
&\quad + \$8,875,000(0.6651) \\
&= \$39,548,212.5
\end{aligned}$$

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