

# HW 1

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25 January 2022

**1.5**

**a**

$$\begin{aligned} A(4) &= \frac{1000}{1 - 0.06 \times 4} \\ &= \frac{1000}{1 - 0.24} \\ &= \frac{1000}{0.76} \\ &= \$1315.79 \end{aligned}$$

**b**

$$\begin{aligned} A(4) &= 1000 \times (1 + 0.06 \times 4) \\ &= 1000 \times (1.24) \\ &= \$1240.00 \end{aligned}$$

**c**

$$\begin{aligned} A(4) &= 1000 \times (1 + 0.06)^4 \\ &= 1000 \times (1.262) \\ &= \$1262.48 \end{aligned}$$

**d**

$$\begin{aligned} r^{(4)} &= 0.06 \\ i(t) &= \left(1 + \frac{r^{(m)}}{m}\right)^m - 1 \\ &= \left(1 + \frac{0.06}{4}\right)^4 - 1 \\ &= (1 + 0.015)^4 - 1 \\ &= 0.0614 \end{aligned}$$

$$\begin{aligned} A(4) &= 1000 \times (1 + 0.0614)^4 \\ &= 1000 \times (1.269) \\ &= \$1268.99 \end{aligned}$$

e

$$\begin{aligned}d^{(12)} &= 0.06 \\i(t) &= \left(1 - \frac{d^{(m)}}{m}\right)^{-m} - 1 \\&= \left(1 - \frac{0.06}{12}\right)^{-12} - 1 \\&= (1 - 0.005)^{-12} - 1 \\&= 0.0620\end{aligned}$$

$$\begin{aligned}A(4) &= 1000 \times (1 + 0.0620)^4 \\&= 1000 \times (1.272) \\&= \$1272.01\end{aligned}$$

f

$$\begin{aligned}A(4) &= 1000 \times e^{\delta t} \\&= 1000 \times e^{0.06 \times 4} \\&= 1000 \times e^{0.24} \\&= 1000 \times (1.271) \\&= \$1271.25\end{aligned}$$

## 1.9

### Present Value

$$\begin{aligned}A(0) &= \sum_{i=1}^5 C_t \times (1 + i)^{-t} \\&= \sum_{i=1}^5 C_t \times (1.02)^{-t} \\&= 950 \times (1.02)^0 + 800 \times (1.02)^{-1} + 150 \times (1.02)^{-2} + 400 \times (1.02)^{-3} + 120 \times (1.02)^{-4} \\&= 950 \times 1 + 800 \times 0.9804 + 150 \times 0.9612 + 400 \times 0.9423 + 120 \times 0.9239 \\&= 950 + 784.314 + 144.175 + 376.9289 + 110.8615 \\&= \$2366.28\end{aligned}$$

### A(5)

To calculate the value in 5 years, we could begin as above, and accumulate each cash flow individually to  $t = 5$  rather than  $t = 0$ . However, it is equivalent to simply accumulate the sum as a whole.

$$\begin{aligned}A(5) &= A(0) \times 1.02^5 \\&= \$2366.28 \times 1.10408 \\&= \$2612.56\end{aligned}$$

## 1.36

To solve for the interest earned in the fifth year, we can subtract  $A(5) - A(4)$

$$\begin{aligned}
A(5) &= A(0) \times \int_0^5 \frac{1}{10(1+t)^3} dt \\
A(4) &= A(0) \times \int_0^4 \frac{1}{10(1+t)^3} dt \\
A(5) - A(4) &= A(0) \times \int_0^5 \frac{1}{10(1+t)^3} dt - A(0) \times \int_0^4 \frac{1}{10(1+t)^3} dt \\
&= A(0) \times \left( \int_0^5 \frac{1}{10(1+t)^3} dt - \int_0^4 \frac{1}{10(1+t)^3} dt \right) \\
&= A(0) \times \left( \int_4^5 \frac{1}{10(1+t)^3} dt \right) \\
&= 100 \times \frac{1}{10} \times \int_4^5 (1+t)^{-3} dt \\
&= 10 \times \left. \frac{-(1+t)^{-2}}{2} \right|_4^5 \\
&= 10 \times \left( \frac{-(1+5)^{-2}}{2} - \frac{-(1+4)^{-2}}{2} \right) \\
&= 5 \times ((1+4)^{-2} - (1+5)^{-2}) \\
&= 5 \times \left( \frac{1}{25} - \frac{1}{36} \right) \\
&= 5 \times (0.0122) \\
&= \$0.0611
\end{aligned}$$

**1.42**

$$a(t) = e^{\int_0^t \delta(s) ds}$$

To solve for  $a_x(t) = a_y(t)$ , we must equate:

$$\begin{aligned}
e^{\int_0^t \delta_x(s) ds} &= e^{\int_0^t \delta_y(s) ds} \\
\int_0^t \delta_x(s) ds &= \int_0^t \delta_y(s) ds
\end{aligned}$$

Observing the graph,  $\delta_x(s) = 0.1t$  for  $t \in [0, 10]$  and  $\delta_y(s) = 0.025t$  for  $t \in [0, 2)$  and  $0.05$  or  $t \in [2, 10]$ .

Thus, integrating both functions to solve for the  $t$  in which they are equal:

$$\begin{aligned}
\Delta_x(t) &= \int_0^t \delta_x(s) ds \\
&= \int_0^t 0.01(s) ds \\
&= 0.005t^2
\end{aligned}$$

$$\begin{aligned}
\Delta_y(t) &= \int_0^t \delta_y(s) ds \\
&= \int_0^t 0.025(s) ds, \quad 0 \leq t \leq 2 \\
&\quad \int_0^2 0.025(s) ds + \int_2^t 0.05 ds, \quad 2 \leq t \leq 10 \\
&= 0.0125t^2, \quad 0 \leq t < 2 \\
&\quad 0.05 + 0.05t - 0.1, \quad 2 \leq t \leq 10 \\
&= 0.0125t^2, \quad 0 \leq t < 2 \\
&\quad -0.05 + 0.05t, \quad 2 \leq t \leq 10 \\
&= 0.0125t^2, \quad 0 \leq t < 2 \\
&\quad 0.05(t - 1), \quad 2 \leq t \leq 10
\end{aligned}$$

Thus, to solve for points where  $0 \leq t < 2$ , we must equate

$$\begin{aligned}
0.005t^2 &= 0.0125t^2 \\
t &= 0
\end{aligned}$$

To solve for points where  $2 \leq t \leq 10$ , we must equate

$$\begin{aligned}
0.005t^2 &= -0.05 + 0.05t \\
0.005t^2 - 0.05t + 0.05 &= 0 \\
0.005(t^2 - 10t + 10) &= 0 \\
t &= 5 \pm \sqrt{15}
\end{aligned}$$

Given the constraint of  $2 \leq t \leq 10$  for this equality, we find  $t = 5 + \sqrt{15} = 8.873$ . Thus, the two solutions are  $t = \{0, 8.873\}$ .

## 2.5

**a**

$$\begin{aligned}
AV(750a_{\bar{8}|4\%}) &= 750 \sum_{k=0}^7 (1.04)^k \\
&= 750(9.21423) \\
&= \$6910.67
\end{aligned}$$

**b**

$$\begin{aligned}
i_{effective} &= 1.04^2 - 1 \\
&= 0.0816 \\
AV(750a_{\bar{8}|8.16\%}) &= 750 \sum_{k=0}^3 (1.0816)^k \\
&= 750(4.51678) \\
&= \$3387.59
\end{aligned}$$

**c**

$$\begin{aligned}i_{effective} &= 1.04^{\frac{1}{2}} - 1 \\ &= 0.0198\end{aligned}$$

$$\begin{aligned}AV(750a_{\overline{8}|1.98\%}) &= 750 \sum_{k=0}^3 (1.0198)^k \\ &= 750(8.57691) \\ &= \$6432.68\end{aligned}$$

## 2.47

**a**

$$Rate(18, -1, 11, 0, 0) = 5.791\%$$

**b**

$$Rate(18, -1, 11, 0, 1) = 6.656\%$$

**c**

$$Rate(18, -1, 0, 28, 0) = 4.949\%$$

**d**

$$Rate(18, -1, 0, 28, 1) = 4.478\%$$

## 2.53

$$\begin{aligned}s_{\overline{2n}|} &= s_{\overline{n}|}(1+i)^{-1} + s_{\overline{n}|} \\ y &= x(1+i)^{-1} + x \\ y &= x((1+i)^{-1} + 1)\end{aligned}$$

$$\begin{aligned}(1+i)^{-1} + 1 &= \frac{y}{x} \\ (1+i)^{-1} &= \frac{y}{x} - 1\end{aligned}$$

$$\begin{aligned}s_{\overline{kn}|} &= s_{\overline{n}|}(1+i)^{-(k-1)} + s_{\overline{n}|} \\ &= x\left(\frac{y}{x} - 1\right)^{k-1} + x \\ &= x\left(\left(\frac{y}{x} - 1\right)^{k-1} + 1\right)\end{aligned}$$

Thus, for  $k = 1$ ,  $s_{\overline{kn}|} = x$ , and for  $k \geq 2$ ,  $s_{\overline{kn}|} = x\left(\left(\frac{y}{x} - 1\right)^{k-1} + 1\right)$

### 3.4

**a**

$$\begin{aligned} i_1^F &= i_1^S \\ &= 2.1\% \end{aligned}$$

$$\begin{aligned} i_2^S &= (1 + i_1^S)(1 + i_2^F) - 1 \\ &= (1.021)(1.026) - 1 \\ &= ((1.021)(1.026))^{\frac{1}{2}} - 1 \\ &= 2.35\% \end{aligned}$$

$$\begin{aligned} i_3^F &= \frac{(1 + i_3^S)^3}{(1 + i_2^S)^2} - 1 \\ &= \frac{(1.031)^3}{(1.0235)^2} - 1 \\ &= \frac{1.0959}{1.0476} - 1 \\ &= 4.62\% \end{aligned}$$

$$\begin{aligned} i_4^S &= ((1 + i_3^S)^3(1 + i_4^F))^{\frac{1}{4}} - 1 \\ &= ((1.031)^3(1.036))^{\frac{1}{4}} - 1 \\ &= 3.22\% \end{aligned}$$

**b**

$$\begin{aligned} \ddot{a}_{\overline{4}|} &= \sum_{k=0}^3 (1 + i_k^S)^{-k} \\ &= 1 + (1 + i_1^S)^{-1} + (1 + i_2^S)^{-2} + (1 + i_3^S)^{-3} \\ &= 1 + (1.021)^{-1} + (1.0235)^{-2} + (1.031)^{-3} \\ &= 3.847 \end{aligned}$$

To calculate  $\ddot{s}_{\overline{4}|}$ , we could accumulate each cash flow individually, or accumulate the sum as a whole as such:

$$\begin{aligned} \ddot{s}_{\overline{4}|} &= \ddot{a}_{\overline{4}|}(1 + i_1^S)^3 \\ &= 3.847(1.031)^3 \\ &= 4.215 \end{aligned}$$

### 3.8

**a**

$$\begin{aligned} 100a_{\overline{4}|} &= 100 \sum_{k=1}^4 (1 + i_k^S)^{-k} \\ &= 100((1.06)^{-1} + (1.07)^{-2} + (1.0775)^{-3} + (1.0825)^{-4}) \\ &= 100(3.344469) \\ &= \$334.47 \end{aligned}$$

**b**

$$\text{Rate}(4, -100, 334.447, 0, 0) = 7.565\%$$

**3.18**

**a**

$$\begin{aligned} R_S &= \frac{\sum_{t=1}^n m_t i_t^F (1 + i_t^S)^{-t}}{\sum_{t=1}^n m_t (1 + i_t^S)^{-t}} \\ &= \frac{\sum_{t=1}^n i_t^F (1 + i_t^S)^{-t}}{\sum_{t=1}^n (1 + i_t^S)^{-t}} \\ &= \frac{i_1^F (1 + i_1^S)^{-1} + i_2^F (1 + i_2^S)^{-2} + i_3^F (1 + i_3^S)^{-3} + i_4^F (1 + i_4^S)^{-4} + i_5^F (1 + i_5^S)^{-5}}{(1 + i_1^S)^{-1} + (1 + i_2^S)^{-2} + (1 + i_3^S)^{-3} + (1 + i_4^S)^{-4} + (1 + i_5^S)^{-5}} \\ &= \frac{0.0071(1.0071)^{-1} + 0.0079(1.0143)^{-2} + 0.0042(1.0205)^{-3} + 0.0031(1.0294)^{-4} + 0.0035(1.0355)^{-5}}{(1.0071)^{-1} + (1.0143)^{-2} + (1.0205)^{-3} + (1.0294)^{-4} + (1.0355)^{-5}} \\ &= 0.0052587 \\ &= 0.53\% \end{aligned}$$

**b**

$$\begin{aligned} R_S &= \frac{\sum_{t=1}^n m_t i_t^F (1 + i_t^S)^{-t}}{\sum_{t=1}^n m_t (1 + i_t^S)^{-t}} \\ &= \frac{m_1 i_1^F (1 + i_1^S)^{-1} + m_2 i_2^F (1 + i_2^S)^{-2} + m_3 i_3^F (1 + i_3^S)^{-3} + m_4 i_4^F (1 + i_4^S)^{-4} + m_5 i_5^F (1 + i_5^S)^{-5}}{m_1 (1 + i_1^S)^{-1} + m_2 (1 + i_2^S)^{-2} + m_3 (1 + i_3^S)^{-3} + m_4 (1 + i_4^S)^{-4} + m_5 (1 + i_5^S)^{-5}} \\ &= \frac{1(0.0071)(1.0071)^{-1} + 3(0.0079)(1.0143)^{-2} + 5(0.0042)(1.0205)^{-3} + 7(0.0031)(1.0294)^{-4} + 9(0.0035)(1.0355)^{-5}}{1(1.0071)^{-1} + 3(1.0143)^{-2} + 5(1.0205)^{-3} + 7(1.0294)^{-4} + 9(1.0355)^{-5}} \\ &= 0.0042678 \\ &= 0.43\% \end{aligned}$$

**c**

$$\begin{aligned} R_S &= \frac{\sum_{t=1}^n m_t i_t^F (1 + i_t^S)^{-t}}{\sum_{t=1}^n m_t (1 + i_t^S)^{-t}} \\ &= \frac{m_1 i_1^F (1 + i_1^S)^{-1} + m_2 i_2^F (1 + i_2^S)^{-2} + m_3 i_3^F (1 + i_3^S)^{-3} + m_4 i_4^F (1 + i_4^S)^{-4} + m_5 i_5^F (1 + i_5^S)^{-5}}{m_1 (1 + i_1^S)^{-1} + m_2 (1 + i_2^S)^{-2} + m_3 (1 + i_3^S)^{-3} + m_4 (1 + i_4^S)^{-4} + m_5 (1 + i_5^S)^{-5}} \\ &= \frac{5(0.0071)(1.0071)^{-1} + 4(0.0079)(1.0143)^{-2} + 3(0.0042)(1.0205)^{-3} + 2(0.0031)(1.0294)^{-4} + 1(0.0035)(1.0355)^{-5}}{5(1.0071)^{-1} + 4(1.0143)^{-2} + 3(1.0205)^{-3} + 2(1.0294)^{-4} + 1(1.0355)^{-5}} \\ &= 0.0060351 \\ &= 0.60\% \end{aligned}$$

**d**

With a level notional contract, the annual fixed rate payment is  $m_t R_S$ , or  $0.00525866(1000000) = \$5258.66$

e

$$\begin{aligned}
MV_3 &= \sum_{k=3}^5 m_k (R_S - i_k^F) \\
&= m_k \sum_{k=3}^5 (R_S - i_k^F) \\
&= 1000000 \sum_{k=3}^5 (R_S - i_k^F) \\
&= 1000000((0.00525866 - 0.0042) + (0.00525866 - 0.0031) + (0.00525866 - 0.0035)) \\
&= 1000000(0.00497598) \\
&= \$4975.98
\end{aligned}$$

f

$$\begin{aligned}
R_S &= \frac{\sum_{t=t^*+1}^n m_t i_t^F (1 + i_t^S)^{-t}}{\sum_{t=t^*+1}^n m_t (1 + i_t^S)^{-t}} \\
&= \frac{\sum_{t=2}^n i_t^F (1 + i_t^S)^{-t}}{\sum_{t=2}^n (1 + i_t^S)^{-t}} \\
&= \frac{i_2^F (1 + i_2^S)^{-2} + i_3^F (1 + i_3^S)^{-3} + i_4^F (1 + i_4^S)^{-4} + i_5^F (1 + i_5^S)^{-5}}{(1 + i_2^S)^{-2} + (1 + i_3^S)^{-3} + (1 + i_4^S)^{-4} + (1 + i_5^S)^{-5}} \\
&= \frac{0.0079(1.0143)^{-2} + 0.0042(1.0205)^{-3} + 0.0031(1.0294)^{-4} + 0.0035(1.0355)^{-5}}{(1.0143)^{-2} + (1.0205)^{-3} + (1.0294)^{-4} + (1.0355)^{-5}} \\
&= 0.0047568 \\
&= 0.48\%
\end{aligned}$$