Name: _____ Class: _____ Date: _____ ID: A

End of Chapter 3 Problems

Numeric Response

1. You bought a bond five years ago for $935 per bond. The bond is now selling for $980. It also paid $75 in interest per year, which you reinvested in the bond. Calculate the realized rate of return earned on this bond.

2. Refer again to the bond information in Question I. You expect to hold the bond for three more years, then sell it for $990. If the bond is expected to continue paying $75 per year over the next three years, what is the expected rate of return on the bond during this period?

3. Johnson Motors' bonds have 10 years remaining to maturity. Interest is paid annually, the bonds have a $1,000 par value, and the coupon rate is 8 percent. The bonds have a yield to maturity of 9 percent. What is the current market price of these bonds?

4. Using a Spreadsheet to Calculate Bond Values. What is the value of $1,000 bond with a 12-year maturity and an 8 percent coupon rate (paid semiannually) if the required return is 5 percent, 6 percent, 8 percent, and 10 percent?

Face value	Total paymens	Periodic Coupon Payment	Required return	The bond value
$1,000	12x2=24	1,000(0.08)/2=40	5%	$1,268.27
1,000	24	40	6	1,169.36
1,000	24	40	8	1,000.00
1,000	24	40	10	862.01

5. A 10-year, 12 percent semiannual coupon bond, with a par value of $1,000 sells for $1,100. What is the bond's yield to maturity?

6. Using a Spreadsheet to Calculate Yield to Maturity. What is the yield to maturity on the following bonds; all have a maturity of 10 years, a face value of $1,000, and a coupon rate of 9 percent (paid semiannually). The bonds' current market values are $945.50, $987.50, $1,090.00, and $1,225.875, respectively.

Market value	Total payments	Periodic coupon payment	Face value	The Yield to Maturity will be
945.50	10x2=20	1,000(0.09)/2=45	1,000	9.87%
987.50	20	45	1,000	9.19
1,090.00	20	45	1,000	7.69
1,225.875	20	45	1,000	5.97

7. Galen Corporation has a bond issue outstanding with an annual coupon rate of 7 percent paid quarterly and 4 years remaining until maturity. The par value of the bond is $1,000. Determine the current value of the bond if market conditions justify a 14 percent, compounded quarterly, required rate of return.

8. You have just been offered a bond for $863.73. The coupon rate is 8 percent payable annually, and interest rates on new issues with the same degree of risk are 10 percent. You want to know how many more interest payments you will receive, but the party selling the bond cannot remember. If the par value is $1,000, how many interest payments remain?

A bond you are evaluating has a 10 percent coupon rate (compounded semiannually), a $1,000 face value, and is 10 years from maturity.

9. Refere to Scenario 3-1. If the required rate of return on the bond is 6 percent, what is its fair present value?

10. Refer to Scenario 3-1. If the required rate of return on the bond is 8 percent, what is its fair present value?

11. Refer to Scenario 3-1. What do your answers to parts (a) and (b) say about the relation between required rates of return and fair values of bonds?

12. For each of the following situations, identify whether a bond would be considered a premium bond, a discount bond, or a par bond.
    a. A bond's current market price is greater than its face value.
    b. A bond's coupon rate is equal to its yield to maturity.
    c. A bond's coupon rate is less than its required rate of return.
    d. A bond's coupon rate is less than its yield to maturity.
    e. A bond's coupon rate is greater than its yield to maturity.
    f. A bond's fair present value is less than its face value.

13. Calculate the yield to maturity on a 9 percent coupon (paid semiannually) bond, with a $1,000 face value and 15 years remaining to maturity. The bond is selling at $985.

14. Calculate the yield to maturity on an 8 percent coupon (paid quarterly) bond, with a $1,000 face value and 10 years remaining to maturity. The bond is selling at $915.

15. Calculate the yield to maturity on an 11 percent coupon (paid annually) bond, with a $1,000 face value and 6 years remaining to maturity. The bond is selling at $1,065.

16. Calculate the fair present values of the following bonds, all of which pay interest semiannually, have a face value of $1,000, have 12 years remaining to maturity, and have a required rate of return of 10 percent.
    a. The bond has a 6 percent coupon rate.
    a. The bond has an 8 percent coupon rate.
    b. The bond has a 10 percent coupon rate.
    c. What do your answers to parts (a) through (c) say about the relation between coupon rates and present values?

17. Repeat parts (a) through (c) of Question 12 using a required rate of return on the bond of 8 percent. What do your calculations imply about the relation between the coupon rates and bond price volatility?

18. Calculate the fair present value of the following bonds, all of which have a 10 percent coupon rate (paid semiannually), face value of $1,000, and a required rate of return of 8 percent.
    a. The bond has 10 years remaining to maturity.
    b. The bond has 15 years remaining to maturity.
    c. The bond has 20 years remaining to maturity.
    d. What do your answers to parts (a) through (c) say about the relation between time to maturity and present values?

19. Repeat parts (a) through (c) of Question 14 using a required rate of return on the bond of II percent. What do your calculations imply about the relation between time to maturity and bond price volatility?

20. Calculate the present value on a stock that pays $5 in dividends per year (with no growth) and has a required rate of return of 10 percent.

21. A stock you are evaluating just paid an annual dividend of $2.50. Dividends have grown at a constant rate of 1.5 percent over the last 15 years and you expect this to continue.
    a. If the required rate of return on the stock is 12 percent, what is its fair present value?
    b. If the required rate of return on the stock is 15 percent, what is its expected price four years from today?

22. You are considering the purchase of a stock that is currently selling at $64 per share. You expect the stock to pay $4.50 in dividends next year.
    a. If dividends are expected to grow at a constant rate of 3 percent per year, what is your expected rate of return on this stock?
    b. If dividends are expected to grow at a constant rate of 5 percent per year, what is your expected rate of return on this stock?
    c. What do your answers to parts (a) and (b) say about the impact of dividend growth rates on expected rate of returns on stocks?

23. A stock you are evaluating is expected to experience supernormal growth in dividends of 8 percent over the next six years. Following this period, dividends are expected to grow at a constant rate of 3 percent. The stock paid a dividend of $5.50 last year and the required rate of return on the stock is 10 percent. Calculate the stock's fair present value.

24. Answer the following questions:
    a. What is the duration of a two-year bond that pays an annual coupon of 10 percent and has a current yield to maturity of 12 percent? Use $1,000 as the face value.
    b. What is the duration of a two-year zero-coupon bond that is yielding 11.5 percent? Use $1,000 as the face value.
    c. Given these answers, how does duration differ from maturity?

25. What is the duration of a zero coupon bond that has 8 years to maturity? What is the duration if the maturity increases to 10 years? If it increases to 12 years?

26. You have discovered that when the required return of a bond you own fell by 0.50 percent from 9.75 percent to 9.25 percent the price rose from $975 to $995. What is the duration of this bond?

Short Answer

27. Go to the S&P Market Insight Web site at www.mhhe.com/edumarketinsight and find the long-term debt outstanding for Alcoa Inc. (AA) and Target Corp. (TOT) using the following steps: Click on "Educational Version of Market Insight" Enter your Site ID and Click on "Login" Click on "Company" Enter "AA" in the "Ticker" box and click on "Go!" Click on "Excel Analytics" Click on "Ann. Balance Sheet" This will download the Balance Sheet for Alcoa, which contains the balances for Fixed Income Securities (or long term debt). Repeat the process by entering "TGT" in the "Ticker" box to get information on Target. If interest rates increase, what will happen to the market values of this debt?

28. What is the economic meaning of duration?

29. Consider the following two banks: Bank I has assets composed solely of a 10-year, 12 percent coupon, $1 million loan with a 12 percent yield to maturity. It is financed with a 10-year, 10 percent coupon, $1 million CD with a 10 percent yield to maturity. Bank 2 has assets composed solely of a 7-year, 12 percent, zero-coupon bond with a current value of $894,006.20 and a maturity value of $1,976,362.88. It is financed by a l0-year, 8.275 percent coupon, $1,000,000 face value CD with a yield to maturity of 10 percent. All securities except the zero-coupon bond pay interest annually.
    a. If interest rates rise by 1 percent (100 basis points), how do the values of the assets and liabilities of each bank change?
    b. What· accounts for the differences between the two banks' accounts?

30. Answer the questions
    a. What is the duration of a five-year Treasury bond with a 10 percent semiannual coupon selling at par?
    b. What is the duration of the above bond if the yield to maturity (ytm) increases to 14 percent? What if the ytm increases to 16 percent?
    c. What can you conclude about the relationship between duration and yield to maturity?

31. Answer the questions
    a. What is the duration of a four-year Treasury bond with a 10 percent semiannual coupon selling at par?
    b. What is the duration of a three-year Treasury bond with a 10 percent semiannual coupon selling at par?
    c. What is the duration of a two-year Treasury bond with a fixed 10 percent semiannual coupon selling at par?
    d. What conclusions can you draw from these results

32. Suppose that you purchase a bond that matures in five years and pays a 13.76 percent coupon rate. The bond is priced to yield 10 percent.

    a. Show that the duration is equal to four years.
    b. Show that if interest rates rise to 11 percent next year and your investment horizon is four years from today, you will still earn a 10 percent yield on your investment.

33. An insurance company is analyzing the following three bonds, each with 5 years to maturity, and is using duration as its measure of interest rate risk:
    a. $10,000 par value, coupon rate = 8%, ytm = .10
    b. $10,000 par value, coupon rate = 10%, ytm = .10
    c. $10,000 par value, coupon rate = 12%, ytm = .10

    What are the durations of each of the three bonds?

34. How is duration related to the interest elasticity of a fixed income security? What is the relationship between duration and the price of a fixed-income security?

End of Chapter 3 Problems
Answer Section

NUMERIC RESPONSE

1. ANS:
   8.83%

   935 = 75(PVIFA $_{rr, 5}$) + 980(PVIF $_{rr, 5}$) ✡ rr = 8.83%

   PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC
2. ANS:
   7.97%

   980 = 75(PVIFA $_{Err, 3}$) + 990(PVIF $_{???, 3}$) ✡ Err = 7.97%

   PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC
3. ANS:
   $935.82

   V_b = 1,000(.08) (PVIFA 9%, 10) + 1,000(PVIF 9%, 10) = $935.82

   PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC
4. ANS:
   Bond Value = $1,268.27
   Bond Value = $1,169.36
   Bond Value = $1,000.00
   Bond Value = $862.01

   PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC
5. ANS:
   10.37%

   . $1,100 = <u>1,000(.12)</u> (PVIFA ytm/2, 10(2)) + 1,000(PVIF ytm/2, 10(2)) => ytm = 10.37%

   PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC
6. ANS:
   Yield to Maturity = 9.87%
   Yield to Maturity = 9.19%
   Yield to Maturity = 7.69%
   Yield to Maturity = 5.97%

   PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

7. ANS:
$788.35

$V_b = \underline{1{,}000(.07)}$ (PVIFA 14%/4, 4(4)) + 1,000(PVIF 14%/4, 4(4)) = $788.35

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

8. ANS:
12

$863.73 = 1,000(.08) (PVIFA 10%, n) + 1,000(PVIF 10%, n) => n = 12 years

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

9. ANS:
$1,297.55

$V_b = \underline{1{,}000(.1)}$ (PVIFA $_{6\%/2,\ 10(2)}$) + 1,000(PVIF $_{6\%/2,\ 10(4)}$) = $1,297.55

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

10. ANS:
$1,135.90

$V_b = \underline{1{,}000(.1)}$ (PVIFA $_{8\%/2,\ 10(2)}$) + 1,000(PVIF $_{8\%/2,\ 10(4)}$) = $1,135.90

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

11. ANS:
negative

From parts a. and b. of this problem, there is a negative relation between required rates and fair values of bonds.

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

12. ANS:
a. Premium bond
b. Par bond
c. Discount bond
d. Discount bond
e. Premium bond
f. Discount bond

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

13. ANS:
9.186%
$985 = \underline{1{,}000(.09)/2}$ (PVIFA $_{ytm/2,\ 15(2)}$) + 1,000(PVIF $_{ytm/2,\ 15(2)}$) ✡ ytm = 9.186%

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

14. ANS:
9.316%
915 = $\underline{1{,}000(.08)/4}$ (PVIFA $_{ytm/4,\ 10(4)}$) + 1,000(PVIF $_{ytm/4,\ 10(4)}$) ✡ ytm = 9.316%

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15. ANS:
9.528%

1,065 = 1,000(.11) (PVIFA $_{ytm,\ 6}$) + 1,000(PVIF $_{ytm,\ 6}$)✡ ytm = 9.528%

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

16. ANS:
$724.03 ; $862.01 ; $1,000.00

a. $V_b = \frac{1{,}000(.06)}{2}$ (PVIFA $_{10\%/2,\ 12(2)}$) + 1,000(PVIF $_{10\%/2,\ 12(2)}$) = $724.03

b. $V_b = \frac{1{,}000(.08)}{2}$ (PVIFA $_{10\%/2,\ 12(2)}$) + 1,000(PVIF $_{10\%/2,\ 12(2)}$) = $862.01

c. $V_b = \frac{1{,}000(.10)}{2}$ (PVIFA $_{10\%/2,\ 12(2)}$) + 1,000(PVIF $_{10\%/2,\ 12(2)}$) = $1,000.00

d. From parts a. through c. in this problem, there is a positive relation between coupon rates and present values of bonds.

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

17. ANS:

a. $V_b = \frac{1{,}000(.06)}{2}$ (PVIFA $_{8\%/2,\ 12(2)}$) + 1,000(PVIF $_{8\%/2,\ 12(2)}$) = $847.53

b. $V_b = \frac{1{,}000(.08)}{2}$ (PVIFA $_{8\%/2,\ 12(2)}$) + 1,000(PVIF $_{8\%/2,\ 12(2)}$) = $1,000.00

% change in bond value versus part (a) = ($1,000 - $847.53)/$847.53 = 17.99%

c. $V_b = \frac{1{,}000(.10)}{2}$ (PVIFA $_{8\%/2,\ 12(2)}$) + 1,000(PVIF $_{8\%/2,\ 12(2)}$) = $1,152.47

% change in bond value versue part (b) = ($1,152.47 - $1,000)/$1,000 = 15.25%

d. From these results we see that as coupon rates increase, price volatility decreases.

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18. ANS:

a. $V_b = \frac{1{,}000(.10)}{2} (PVIFA_{8\%/2,\ 10(2)}) + 1{,}000(PVIF_{8\%/2,\ 10(2)}) = \$1{,}135.90$

b. $V_b = \frac{1{,}000(.10)}{2} (PVIFA_{8\%/2,\ 15(2)}) + 1{,}000(PVIF_{8\%/2,\ 15(2)}) = \$1{,}172.92$

c. $V_b = \frac{1{,}000(.10)}{2} (PVIFA_{8\%/2,\ 20(2)}) + 1{,}000(PVIF_{8\%/2,\ 20(2)}) = \$1{,}197.93$

d. From these results we see that there is a positive relation between time to maturity and the difference between present values and face values on bonds.

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19. ANS:

a. $V_b = \frac{1{,}000(.10)}{2} (PVIFA_{11\%/2,\ 10(2)}) + 1{,}000(PVIF_{11\%/2,\ 10(2)}) = \$940.25$

% change in bond value = ($940.25 - $1,135.90)/$1,135.90 = -17.22%

b. $V_b = \frac{1{,}000(.10)}{2} (PVIFA_{11\%/2,\ 15(2)}) + 1{,}000(PVIF_{11\%/2,\ 15(2)}) = \$927.33$ % change 3.72%

% change in bond value = ($927.33 - $1,172.92)/$1,172.92 = -20.94%

c. $V_b = \frac{1{,}000(.10)}{2} (PVIFA_{11\%/2,\ 20(2)}) + 1{,}000(PVIF_{11\%/2,\ 20(2)}) = \$919.77$ % change 2.28%

% change in bond value = ($919.77 - $1,197.93)/$1,197.93 = -23.22%

d. As interest rates increase the variability in bond prices increases as time to maturity increases.

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20. ANS:

50

$P_0 = 5/.10 = \$50$

PTS: 10 BNK: Chapter 03 – Interest rates and security valuatio, EOC

21. ANS:

$24.167; $19.95

a. $P_o = \frac{2.50(1 + .015)}{.12 - .015} = \$24.167$

b. $P_4 = \frac{2.50(1 + .015)^5}{.15 - .015} = \$19.95$

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22. ANS:
10.03%; 12.03%

a. $i_s = \frac{4.50}{64} + .03 = 10.03\%$

b. $i_s = \frac{4.50}{64} + .05 = 12.03\%$

c. From parts a. and b. of this problem, there is a positive relation between the dividend growth rate and the expected rate of return on stocks.

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23. ANS:
$103.455

Step 1: Find the present value of dividends during the period of supernormal growth.

Year	Dividends ($D_0(1 + g_s)^t$)		$PVIF_{10\%, t}$	Present Value
1	$5.5(1 + .08)^1 = 5.940$	.9091	5.400	
2	$5.5(1 + .08)^2 = 6.415$	.8264	5.302	
3	$5.5(1 + .08)^3 = 6.928$	.7513	5.205	
4	$5.5(1 + .08)^4 = 7.483$	.6830	5.111	
5	$5.5(1 + .08)^5 = 8.081$	.6209	5.018	
6	$5.5(1 + .08)^6 = 8.728$	.5645	4.927	

Present value of dividends during supernormal growth period $30.963

Step 2: Find present value of dividends after period of supernormal growth

a. Find stock value at beginning of constant growth period

$$P_6 = \frac{D_7}{k_s - g} = \frac{D_0(1 + g_s)^6(1 + g)^1}{k_s - g} = \frac{5.5\ (1 + .08\ )^6(1 + .03)^1}{.10 - .03} = \$128.423$$

b. Find present value of constant growth dividends

$$P_0 = P_6(PVIF_{10\%,6}) = 128.423(.5645) = \$72.492$$

Step 3: Find present value of stock = value during supernormal growth period + value during normal growth period $30.963 + $72.492 = $103.455

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24. ANS:
1.9076 years, 2 years

Year	Cash Flows (CF)	PVIF $_{12\%,t}$	PV of CF	PV of CF ✞ t
1	100	0.8929	89.29	89.29
2	1,100	0.7972	876.91	1,753.83
			966.20	1,843.12

Duration = $1,843.12/$966.20 = 1.9076 years

b. The duration of a two-year zero coupon bond is 2 years.
c. Duration always will be lower than the maturity of a fixed-income instrument. That is because duration takes into account the timing of cash flows. The only time duration equals maturity is when there is only one single payment, as with zero-coupon bonds.

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25. ANS: 8, 10, 12

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26. ANS:
4.5
We know -D = (dP/P)/(dr/(1+R)), so -D = (20/975)/(-.005/1.0975) =- 4.5 years; D = 4.5 years.

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SHORT ANSWER

27. ANS:
will depend on the date of the assignment.

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28. ANS:
Duration, which measures the average life of the asset or liability, also has economic meaning as the interest sensitivity (or interest elasticity) of that asset■s or liability■s value. That is, duration describes the percentage price fall or capital loss of the bond (*dP*/*P*) for any given (present value) increase in required interest rates or yields (dR/1+ R).

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29. ANS:

a. If interest rates rise by 1%, the value of the Bank 1's loan will be
$945,737.56 = 120,000 (PVIFA $_{13\%, 10}$) +1,000,000(PVIF $_{13\%, 10}$).
The value of the CD will be $941,107.68 = 100,000(PVIFA $_{11\%, 10}$) + 1,000,000(PVIF $_{11\%, 10}$).
The asset decreased in value by less than the liability. The difference in the changes is $4,630.

The value of the zero coupon bond when rates rise by 1% is
$840,074.10 = 1,976,362.88(PVIF $_{13\%, 7}$).
The value of the Bank 2's CD was $894,006.2 and is now $839,518.43. The difference in the changes in the assets ($53,932.10) and liabilities ($54,487.77) is $556.

b. Although the numbers are a bit contrived, the point of the problem is to show that in part a even though Bank 1's assets and liabilities had the same face values and maturities, they have different durations and so the changes in prices because of a change in interest rates was different for the assets compared to the liability. Bank 2's assets and liabilities have the same current values, but different maturities. But students can verify that the duration of the asset is about the same as the duration of the liability. Consequently, a one percent change in interest rates produces approximately the same change in the prices of the asset and liability.

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30. ANS:
D = 4.05 years

Time	cash flow	PVIF	PVCF	PVCF*t
0.5	50	0.9524	47.620	23.810
1.0	50	0.9070	45.350	45.350
1.5	50	0.8638	43.190	64.785
2.0	50	0.8227	41.135	82.270
2.5	50	0.7835	39.175	97.937
3.0	50	0.7462	37.310	111.930
3.5	50	0.7107	35.535	124.373
4.0	50	0.6768	33.842	135.368
4.5	50	0.6446	32.230	145.035
5.0	1,050	0.6139	644.595	3,222.975
			1,000.00	4,053.833

b. Duration for a 14% yield to maturity = 3409.95/859.53 = 3.97 years

Duration for a 16% yield to maturity = 3133.14/798.7 = 3.92 years

c. From this we see that as yield to maturity increases, duration decreases.

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31. ANS:
D = 3,393.18/1,000 = 3.39 years

Time	cash flow	PVIF	PVCF	PVCF*t
0.5	50	.9524	47.62	23.81
1.0	50	.9070	45.35	45.35
1.5	50	.8638	43.19	64.79
2.0	50	.8227	41.14	82.27
2.5	50	.7835	39.18	97.94
3.0	50	.7462	37.31	111.93
3.5	50	.7107	35.53	124.37
4.0	1,050	.6768	710.68	2,842.72
			$1,000	$3,393.18

b. Duration on a 3-year bond = 2,664.74/1,000 = 2.66 years

c. Duration on a 2-year bond = 1,861.62/1,000 = 1.86 years

d. As maturity increases, duration increases but at a decreasing rate.

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32. ANS:
a. Duration = 4,570.4/1,142.53 = 4 years

Time	cash flow	PVIF	PVCF	PVCF*t
1.0	137.6	.9091	125.091	125.091
2.0	137.6	.8264	113.719	227.438
3.0	137.6	.7513	103.381	310.143
4.0	137.6	.6830	93.983	375.931
5.0	1,137.6	.6209	706.360	3,531.800
			$1,142.534	$4,570.403

b. The cash flows from this investment during the four-year investment horizon will be -$1,142.53 at time zero + 137.6 (FVIFA $_{11\%, 4}$) for the future value of the interest payment reinvested at 11% + 1,024.87 the present value of $1,000 + $137.6 at the 11% discount rate.

The three cash flows are $1,142.53 at time 0, and $648.06 + $1,024.86 at time 4 . These cash flows have an IRR of 10%.

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33. ANS:

a. Duration = 39,568.13/9,24184 = 4.28 years

Time	cash flow	PVIF	PVCF	PVCF*t	
1.0	800	.9091	727.27	727.27	
2.0	800		.8264	661.16	1322.31
3.0	800	.7513	601.05	1803.16	
4.0	800	.6830	546.41	2185.64	
5.0	10,800	.6209	6705.95	33,529.75	
			$9,241.84	$39,568.13	

b. Duration on 10% coupon bond = 4.17 years

c. Duration on 12% coupon bond = 4.07 years

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34. ANS:
Taking the first derivative of a bond's (fixed income security's) price (P) with respect to yield to maturity (R) provides us with the following:

$$\frac{\frac{dP}{P}}{\frac{dR}{(1+R)}} = -D$$

The economic interpretation is that D is a measure of the percentage change in price of a bond for a percentage change in yield to maturity (interest elasticity). This equation can be rewritten to provide a practical application:

$$dP = -D\left[\frac{dR}{1+R}\right]P$$

In other words, if duration is known, then the change in the price of a bond due to small changes in interest rates, R, can be estimated using the above formula.

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