- When the yield curve is not flat, bonds with the same maturity but different coupon rates will have different yields to maturity.

6.4 Corporate Bonds

- When a bond issuer does not make a bond payment in full, the issuer has defaulted.
  - The risk that default can occur is called default or credit risk.
  - U.S. Treasury securities are generally considered free of default risk.
- The expected return of a corporate bond, which is the firm's debt cost of capital, equals the risk-free rate of interest plus a risk premium. The expected return is less than the bond's yield to maturity because the yield to maturity of a bond is calculated using the promised cash flows, not the expected cash flows.
- Bond ratings summarize the creditworthiness of bonds for investors.
- The difference between yields on Treasury securities and yields on corporate bonds is called the credit spread or default spread. The credit spread compensates investors for the difference between promised and expected cash flows and for the risk of default.

6.5 Sovereign Bonds

- Sovereign bonds are issued by national governments.
- Sovereign bond yields reflect investor expectations of inflation, currency, and default risk.
- Countries may repay their debt by printing additional currency, which generally leads to a rise in inflation and a sharp currency devaluation.
- When "inflating away" the debt is infeasible or politically unattractive, countries may choose to default on their debt.

Key Terms

bond certificate *p. 170*
clean price *p. 179*
corporate bonds *p. 184*
coupon bonds *p. 173*
coupon-paying yield curve *p. 184*
coupon rate *p. 170*
coupons *p. 170*
credit risk *p. 185*
debt ceiling *p. 185*
default (credit) spread *p. 188*
dirty price *p. 179*
discount *p. 170*
duration *p. 179*
face value *p. 170*
high-yield bonds *p. 188*
investment-grade bonds *p. 188*
invoice price *p. 179*
junk bonds *p. 188*
maturity date *p. 170*
on-the-run bonds *p. 184*
par *p. 175*
premium *p. 175*
pure discount bond *p. 170*
sovereign bonds *p. 188*
speculative bonds *p. 188*
spot interest rates *p. 172*
term *p. 170*
Treasury bills *p. 170*
Treasury bonds *p. 173*
Treasury notes *p. 173*
yield to maturity (YTM) *p. 171*
zero-coupon bond *p. 170*
zero-coupon yield curve *p. 172*

Further Reading

For readers interested in more details about the bond market, the following texts will prove useful: Z. Bodie, A. Kane, and A. Marcus, *Investments* (McGraw-Hill/Irwin, 2004); F. Fabozzi, *The Handbook of Fixed Income Securities* (McGraw-Hill, 2005); W. Sharpe, G. Alexander, and J. Bailey, *Investments* (Prentice-Hall, 1998); and B. Tuckman, *Fixed Income Securities: Tools for Today's Markets* (John Wiley & Sons, Inc., 2002). C. Reinhart and K. Rogoff, *This Time Is Different* (Princeton University Press, 2010), provides a historical perspective and an excellent discussion of the risk of sovereign debt.

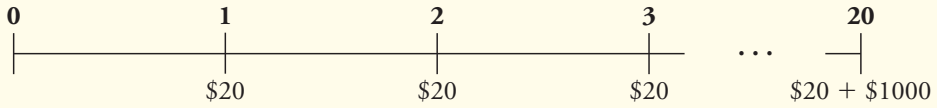
Problems

All problems are available in MyFinanceLab. An asterisk (*) indicates problems with a higher level of difficulty.

Bond Cash Flows, Prices, and Yields

1. A 30-year bond with a face value of $1000 has a coupon rate of 5.5%, with semiannual payments.
   a. What is the coupon payment for this bond?
   b. Draw the cash flows for the bond on a timeline.

2. Assume that a bond will make payments every six months as shown on the following timeline (using six-month periods):



   a. What is the maturity of the bond (in years)?
   b. What is the coupon rate (in percent)?
   c. What is the face value?

3. The following table summarizes prices of various default-free, zero-coupon bonds (expressed as a percentage of face value):

Maturity (years)	1	2	3	4	5
Price (per $100 face value)	$95.51	$91.05	$86.38	$81.65	$76.51

   a. Compute the yield to maturity for each bond.
   b. Plot the zero-coupon yield curve (for the first five years).
   c. Is the yield curve upward sloping, downward sloping, or flat?

4. Suppose the current zero-coupon yield curve for risk-free bonds is as follows:

Maturity (years)	1	2	3	4	5
YTM	5.00%	5.50%	5.75%	5.95%	6.05%

   a. What is the price per $100 face value of a two-year, zero-coupon, risk-free bond?
   b. What is the price per $100 face value of a four-year, zero-coupon, risk-free bond?
   c. What is the risk-free interest rate for a five-year maturity?

5. In the Global Financial Crisis box in Section 6.1, Bloomberg.com reported that the three-month Treasury bill sold for a price of $100.002556 per $100 face value. What is the yield to maturity of this bond, expressed as an EAR?

6. Suppose a 10-year, $1000 bond with an 8% coupon rate and semiannual coupons is trading for a price of $1034.74.
   a. What is the bond's yield to maturity (expressed as an APR with semiannual compounding)?
   b. If the bond's yield to maturity changes to 9% APR, what will the bond's price be?

7. Suppose a five-year, $1000 bond with annual coupons has a price of $900 and a yield to maturity of 6%. What is the bond's coupon rate?

Dynamic Behavior of Bond Prices

8. The prices of several bonds with face values of $1000 are summarized in the following table:

Bond	A	B	C	D
Price	$972.50	$1040.75	$1150.00	$1000.00

For each bond, state whether it trades at a discount, at par, or at a premium.

9. Explain why the yield of a bond that trades at a discount exceeds the bond's coupon rate.

10. Suppose a seven-year, $1000 bond with an 8% coupon rate and semiannual coupons is trading with a yield to maturity of 6.75%.
a. Is this bond currently trading at a discount, at par, or at a premium? Explain.
b. If the yield to maturity of the bond rises to 7% (APR with semiannual compounding), what price will the bond trade for?

11. Suppose that General Motors Acceptance Corporation issued a bond with 10 years until maturity, a face value of $1000, and a coupon rate of 7% (annual payments). The yield to maturity on this bond when it was issued was 6%.
a. What was the price of this bond when it was issued?
b. Assuming the yield to maturity remains constant, what is the price of the bond immediately before it makes its first coupon payment?
c. Assuming the yield to maturity remains constant, what is the price of the bond immediately after it makes its first coupon payment?

12. Suppose you purchase a 10-year bond with 6% annual coupons. You hold the bond for four years, and sell it immediately after receiving the fourth coupon. If the bond's yield to maturity was 5% when you purchased and sold the bond,
a. What cash flows will you pay and receive from your investment in the bond per $100 face value?
b. What is the internal rate of return of your investment?

13. Consider the following bonds:

Bond	Coupon Rate (annual payments)	Maturity (years)
A	0%	15
B	0%	10
C	4%	15
D	8%	10

a. What is the percentage change in the price of each bond if its yield to maturity falls from 6% to 5%?
b. Which of the bonds A–D is most sensitive to a 1% drop in interest rates from 6% to 5% and why? Which bond is least sensitive? Provide an intuitive explanation for your answer.

14. Suppose you purchase a 30-year, zero-coupon bond with a yield to maturity of 6%. You hold the bond for five years before selling it.
a. If the bond's yield to maturity is 6% when you sell it, what is the internal rate of return of your investment?
b. If the bond's yield to maturity is 7% when you sell it, what is the internal rate of return of your investment?
c. If the bond's yield to maturity is 5% when you sell it, what is the internal rate of return of your investment?
d. Even if a bond has no chance of default, is your investment risk free if you plan to sell it before it matures? Explain.

15. Suppose you purchase a 30-year Treasury bond with a 5% annual coupon, initially trading at par. In 10 years' time, the bond's yield to maturity has risen to 7% (EAR).
a. If you sell the bond now, what internal rate of return will you have earned on your investment in the bond?
b. If instead you hold the bond to maturity, what internal rate of return will you earn on your investment in the bond?
c. Is comparing the IRRs in (a) versus (b) a useful way to evaluate the decision to sell the bond? Explain.

16. Suppose the current yield on a one-year, zero coupon bond is 3%, while the yield on a five-year, zero coupon bond is 5%. Neither bond has any risk of default. Suppose you plan to invest for

one year. You will earn more over the year by investing in the five-year bond as long as its yield does not rise above what level?

The Yield Curve and Bond Arbitrage

For Problems 17–22, assume zero-coupon yields on default-free securities are as summarized in the following table:

Maturity (years)	1	2	3	4	5
Zero-coupon YTM	4.00%	4.30%	4.50%	4.70%	4.80%

17. What is the price today of a two-year, default-free security with a face value of $1000 and an annual coupon rate of 6%? Does this bond trade at a discount, at par, or at a premium?

18. What is the price of a five-year, zero-coupon, default-free security with a face value of $1000?

19. What is the price of a three-year, default-free security with a face value of $1000 and an annual coupon rate of 4%? What is the yield to maturity for this bond?

20. What is the maturity of a default-free security with annual coupon payments and a yield to maturity of 4%? Why?

***21.** Consider a four-year, default-free security with annual coupon payments and a face value of $1000 that is issued at par. What is the coupon rate of this bond?

22. Consider a five-year, default-free bond with annual coupons of 5% and a face value of $1000.
a. Without doing any calculations, determine whether this bond is trading at a premium or at a discount. Explain.
b. What is the yield to maturity on this bond?
c. If the yield to maturity on this bond increased to 5.2%, what would the new price be?

***23.** Prices of zero-coupon, default-free securities with face values of $1000 are summarized in the following table:

Maturity (years)	1	2	3
Price (per $1000 face value)	$970.87	$938.95	$904.56

Suppose you observe that a three-year, default-free security with an annual coupon rate of 10% and a face value of $1000 has a price today of $1183.50. Is there an arbitrage opportunity? If so, show specifically how you would take advantage of this opportunity. If not, why not?

***24.** Assume there are four default-free bonds with the following prices and future cash flows:

		Cash Flows		
Bond	Price Today	Year 1	Year 2	Year 3
A	$934.58	1000	0	0
B	881.66	0	1000	0
C	1,118.21	100	100	1100
D	839.62	0	0	1000

Do these bonds present an arbitrage opportunity? If so, how would you take advantage of this opportunity? If not, why not?

***25.** Suppose you are given the following information about the default-free, coupon-paying yield curve:

Maturity (years)	1	2	3	4
Coupon rate (annual payments)	0.00%	10.00%	6.00%	12.00%
YTM	2.000%	3.908%	5.840%	5.783%

a. Use arbitrage to determine the yield to maturity of a two-year, zero-coupon bond.
b. What is the zero-coupon yield curve for years 1 through 4?

Corporate Bonds

26. Explain why the expected return of a corporate bond does not equal its yield to maturity.

27. Grummon Corporation has issued zero-coupon corporate bonds with a five-year maturity. Investors believe there is a 20% chance that Grummon will default on these bonds. If Grummon does default, investors expect to receive only 50 cents per dollar they are owed. If investors require a 6% expected return on their investment in these bonds, what will be the price and yield to maturity on these bonds?

28. The following table summarizes the yields to maturity on several one-year, zero-coupon securities:

Security	Yield (%)
Treasury	3.1
AAA corporate	3.2
BBB corporate	4.2
B corporate	4.9

a. What is the price (expressed as a percentage of the face value) of a one-year, zero-coupon corporate bond with a AAA rating?
b. What is the credit spread on AAA-rated corporate bonds?
c. What is the credit spread on B-rated corporate bonds?
d. How does the credit spread change with the bond rating? Why?

29. Andrew Industries is contemplating issuing a 30-year bond with a coupon rate of 7% (annual coupon payments) and a face value of $1000. Andrew believes it can get a rating of A from Standard and Poor's. However, due to recent financial difficulties at the company, Standard and Poor's is warning that it may downgrade Andrew Industries bonds to BBB. Yields on A-rated, long-term bonds are currently 6.5%, and yields on BBB-rated bonds are 6.9%.
a. What is the price of the bond if Andrew maintains the A rating for the bond issue?
b. What will the price of the bond be if it is downgraded?

30. HMK Enterprises would like to raise $10 million to invest in capital expenditures. The company plans to issue five-year bonds with a face value of $1000 and a coupon rate of 6.5% (annual payments). The following table summarizes the yield to maturity for five-year (annual-pay) coupon corporate bonds of various ratings:

Rating	AAA	AA	A	BBB	BB
YTM	6.20%	6.30%	6.50%	6.90%	7.50%

a. Assuming the bonds will be rated AA, what will the price of the bonds be?
b. How much total principal amount of these bonds must HMK issue to raise $10 million today, assuming the bonds are AA rated? (Because HMK cannot issue a fraction of a bond, assume that all fractions are rounded to the nearest whole number.)
c. What must the rating of the bonds be for them to sell at par?
d. Suppose that when the bonds are issued, the price of each bond is $959.54. What is the likely rating of the bonds? Are they junk bonds?

31. A BBB-rated corporate bond has a yield to maturity of 8.2%. A U.S. Treasury security has a yield to maturity of 6.5%. These yields are quoted as APRs with semiannual compounding. Both bonds pay semiannual coupons at a rate of 7% and have five years to maturity.
a. What is the price (expressed as a percentage of the face value) of the Treasury bond?
b. What is the price (expressed as a percentage of the face value) of the BBB-rated corporate bond?
c. What is the credit spread on the BBB bonds?

32. The Isabelle Corporation rents prom dresses in its stores across the southern United States. It has just issued a five-year, zero-coupon corporate bond at a price of $74. You have purchased this bond and intend to hold it until maturity.
   a. What is the yield to maturity of the bond?
   b. What is the expected return on your investment (expressed as an EAR) if there is no chance of default?
   c. What is the expected return (expressed as an EAR) if there is a 100% probability of default and you will recover 90% of the face value?
   d. What is the expected return (expressed as an EAR) if the probability of default is 50%, the likelihood of default is higher in bad times than good times, and, in the case of default, you will recover 90% of the face value?
   e. For parts (b–d), what can you say about the five-year, risk-free interest rate in each case?

Sovereign Debt

33. What does it mean for a country to "inflate away" its debt? Why might this be costly for investors even if the country does not default?

34. Suppose the yield on German government bonds is 1%, while the yield on Spanish government bonds is 6%. Both bonds are denominated in euros. Which country do investors believe is more likely to default? Why?

Data Case

You are an intern with Sirius Satellite Radio in their corporate finance division. The firm is planning to issue $50 million of 12% annual coupon bonds with a 10-year maturity. The firm anticipates an increase in its bond rating. Your boss wants you to determine the gain in the proceeds of the new issue if the issue is rated above the firm's current bond rating. To prepare this information, you will have to determine Sirius' current debt rating and the yield curve for their particular rating.

1. Begin by finding the current U.S. Treasury yield curve. At the Treasury Web site (www.treas.gov), search using the term "yield curve" and select "Historic Yield Data." Click on "View Text Version of Treasury Yield Curve." The correct link is likely to be the first link on the page. Download that table into Excel by right clicking with the cursor in the table and selecting "Export to Microsoft Excel."

2. Find the current yield spreads for the various bond ratings. Unfortunately, the current spreads are available only for a fee, so you will use old ones. Go to BondsOnline (www.bondsonline.com) and click "Today's Market." Next, click "Corporate Bond Spreads." Download this table to Excel and copy and paste it to the same file as the Treasury yields.

3. Find the current bond rating for Sirius. Go to Standard & Poor's Web site (www.standardandpoors.com). Select "Find a Rating" from the list at the left of the page, then select "Credit Ratings Search." At this point, you will have to register (it's free) or enter the username and password provided by your instructor. Next, you will be able to search by Organization Name—enter Sirius and select Sirius Satellite Radio. Use the credit rating for the organization, not the specific issue ratings.

4. Return to Excel and create a timeline with the cash flows and discount rates you will need to value the new bond issue.
   a. To create the required spot rates for Sirius' issue, add the appropriate spread to the Treasury yield of the same maturity.
   b. The yield curve and spread rates you have found do not cover every year that you will need for the new bonds. Specifically, you do not have yields or spreads for four-, six-, eight-, and nine-year maturities. Fill these in by linearly interpolating the given yields and spreads. For example, the four-year spot rate and spread will be the average of the three- and five-year rates. The six-year rate and spread will be the average of the five- and seven-year rates. For years 8 and 9 you will have to spread the difference between years 7 and 10 across the two years.

c. To compute the spot rates for Sirius' current debt rating, add the yield spread to the Treasury rate for each maturity. However, note that the spread is in basis points, which are 1/100th of a percentage point.
d. Compute the cash flows that would be paid to bondholders each year and add them to the timeline.

5. Use the spot rates to calculate the present value of each cash flow paid to the bondholders.
6. Compute the issue price of the bond and its initial yield to maturity.
7. Repeat Steps 4–6 based on the assumption that Sirius is able to raise its bond rating by one level. Compute the new yield based on the higher rating and the new bond price that would result.
8. Compute the additional cash proceeds that could be raised from the issue if the rating were improved.

CHAPTER 6 APPENDIX

NOTATION

f_n one-year forward rate for year n

Forward Interest Rates

Given the risk associated with interest rate changes, corporate managers require tools to help manage this risk. One of the most important is the interest rate forward contract, which is a type of swap contract. An **interest rate forward contract** (also called a **forward rate agreement**) is a contract today that fixes the interest rate for a loan or investment in the future. In this appendix, we explain how to derive forward interest rates from zero-coupon yields.

Computing Forward Rates

A **forward interest rate** (or **forward rate**) is an interest rate that we can guarantee today for a loan or investment that will occur in the future. Throughout this section, we will consider interest rate forward contracts for one-year investments; thus, when we refer to the forward rate for year 5, we mean the rate available *today* on a one-year investment that begins four years from today and is repaid five years from today.

We can use the Law of One Price to calculate the forward rate from the zero-coupon yield curve. The forward rate for year 1 is the rate on an investment that starts today and is repaid in one year; it is equivalent to an investment in a one-year, zero-coupon bond. Therefore, by the Law of One Price, these rates must coincide:

$$f_1 = YTM_1 \tag{6A.1}$$

Now consider the two-year forward rate. Suppose the one-year, zero-coupon yield is 5.5% and the two-year, zero-coupon yield is 7%. There are two ways to invest money risk free for two years. First, we can invest in the two-year, zero-coupon bond at rate of 7% and earn $\$(1.07)^2$ after two years per dollar invested. Second, we can invest in the one-year bond at a rate of 5.5%, which will pay \$1.055 at the end of one year, and simultaneously guarantee the interest rate we will earn by reinvesting the \$1.055 for the second year by entering into an interest rate forward contract for year 2 at rate f_2. In that case, we will earn $\$(1.055)(1 + f_2)$ at the end of two years. Because both strategies are risk free, by the Law of One Price, they must have the same return:

$$(1.07)^2 = (1.055)(1 + f_2)$$

Rearranging, we have

$$(1 + f_2) = \frac{1.07^2}{1.055} = 1.0852$$

Therefore, in this case the forward rate for year 2 is $f_2 = 8.52\%$.

In general, we can compute the forward rate for year n by comparing an investment in an n-year, zero-coupon bond to an investment in an $(n - 1)$ year, zero-coupon bond, with the interest rate earned in the nth year being guaranteed through an interest rate forward contract. Because both strategies are risk free, they must have the same payoff or else an arbitrage opportunity would be available. Comparing the payoffs of these strategies, we have

$$(1 + YTM_n)^n = (1 + YTM_{n-1})^{n-1}(1 + f_n)$$

We can rearrange this equation to find the general formula for the forward interest rate:

$$f_n = \frac{(1 + YTM_n)^n}{(1 + YTM_{n-1})^{n-1}} - 1 \tag{6A.2}$$

EXAMPLE 6A.1 Computing Forward Rates

Problem

Calculate the forward rates for years 1 through 5 from the following zero-coupon yields:

Maturity	1	2	3	4
YTM	5.00%	6.00%	6.00%	5.75%

Solution

Using Eqs. 6A.1 and 6A.2:

$$f_1 = YTM_1 = 5.00\%$$

$$f_2 = \frac{(1 + YTM_2)^2}{(1 + YTM_1)} - 1 = \frac{1.06^2}{1.05} - 1 = 7.01\%$$

$$f_3 = \frac{(1 + YTM_3)^3}{(1 + YTM_2)^2} - 1 = \frac{1.06^3}{1.06^2} - 1 = 6.00\%$$

$$f_4 = \frac{(1 + YTM_4)^4}{(1 + YTM_3)^3} - 1 = \frac{1.0575^4}{1.06^3} - 1 = 5.00\%$$

Note that when the yield curve is increasing in year n (that is, when $YTM_n > YTM_{n-1}$), the forward rate is higher than the zero-coupon yield, $f_n > YTM_n$. Similarly, when the yield curve is decreasing, the forward rate is less than the zero-coupon yield. When the yield curve is flat, the forward rate equals the zero-coupon yield.

Computing Bond Yields from Forward Rates

Eq. 6A.2 computes the forward interest rate using the zero-coupon yields. It is also possible to compute the zero-coupon yields from the forward interest rates. To see this, note that if we use interest rate forward contracts to lock in an interest rate for an investment in year 1, year 2, and so on through year n, we can create an n-year, risk-free investment. The return from this strategy must match the return from an n-year, zero-coupon bond. Therefore,

$$(1 + f_1) \times (1 + f_2) \times \cdots \times (1 + f_n) = (1 + YTM_n)^n \tag{6A.3}$$

For example, using the forward rates from Example 6A.1, we can compute the four-year zero-coupon yield:

$$\begin{aligned} 1 + YTM_4 &= [(1 + f_1)(1 + f_2)(1 + f_3)(1 + f_4)]^{1/4} \\ &= [(1.05)(1.0701)(1.06)(1.05)]^{1/4} \\ &= 1.0575 \end{aligned}$$

Forward Rates and Future Interest Rates

A forward rate is the rate that you contract for today for an investment in the future. How does this rate compare to the interest rate that will actually prevail in the future? It is tempting to believe that the forward interest rate should be a good predictor of future interest rates. In reality, this will generally not be the case. Instead, it is a good predictor only when investors do not care about risk.

EXAMPLE 6A.2 Forward Rates and Future Spot Rates

Problem

JoAnne Wilford is corporate treasurer for Wafer Thin Semiconductor. She must invest some of the cash on hand for two years in risk-free bonds. The current one-year, zero-coupon yield is 5%. The one-year forward rate is 6%. She is trying to decide between three possible strategies: (1) buy a two-year bond, (2) buy a one-year bond and enter into an interest rate forward contract to guarantee the rate in the second year, or (3) buy a one-year bond and forgo the forward contract, reinvesting at whatever rate prevails next year. Under what scenarios would she be better off following the risky strategy?

Solution

From Eq. 6A.3, both strategies (1) and (2) lead to the same risk-free return of $(1 + YTM_2)^2 = (1 + YTM_1)(1 + f_2) = (1.05)(1.06)$. The third strategy returns $(1.05)(1 + r)$, where r is the one-year interest rate next year. If the future interest rate turns out to be 6%, then the two strategies will offer the same return. Otherwise Wafer Thin Semiconductor is better off with strategy (3) if the interest rate next year is greater than the forward rate—6%—and worse off if the interest rate is lower than 6%.

As Example 6A.2 makes clear, we can think of the forward rate as a break-even rate. If this rate actually prevails in the future, investors will be indifferent between investing in a two-year bond and investing in a one-year bond and rolling over the money in one year. If investors did not care about risk, then they would be indifferent between the two strategies whenever the expected one-year spot rate equals the current forward rate. However, investors *do* generally care about risk. If the expected returns of both strategies were the same, investors would prefer one strategy or the other depending on whether they want to be exposed to future interest rate risk fluctuations. In general, the expected future spot interest rate will reflect investors' preferences toward the risk of future interest rate fluctuations. Thus,

$$\text{Expected Future Spot Interest Rate} = \text{Forward Interest Rate} + \text{Risk Premium} \quad (6A.4)$$

This risk premium can be either positive or negative depending on investors' preferences.[6] As a result, forward rates tend not to be ideal predictors of future spot rates.

[6]Empirical research suggests that the risk premium tends to be negative when the yield curve is upward sloping, and positive when it is downward sloping. See E. Fama and R. Bliss, "The Information in Long-Maturity Forward Rates," *American Economic Review* 77(4) (1987): 680–692; and J. Campbell and R. Shiller, "Yield Spreads and Interest Rate Movements: A Bird's Eye View," *Review of Economic Studies* 58(3) (1991): 495–514.

Key Terms

forward interest rate (forward rate) *p. 201*
forward rate agreement *p. 201*
interest rate forward contract *p. 201*

Problems

All problems are available in MyFinanceLab. *An asterisk (*) indicates problems with a higher level of difficulty.*

Problems A.1–A.4 refer to the following table:

Maturity (years)	1	2	3	4	5
Zero-coupon YTM	4.0%	5.5%	5.5%	5.0%	4.5%

A.1. What is the forward rate for year 2 (the forward rate quoted today for an investment that begins in one year and matures in two years)?

A.2. What is the forward rate for year 3 (the forward rate quoted today for an investment that begins in two years and matures in three years)? What can you conclude about forward rates when the yield curve is flat?

A.3. What is the forward rate for year 5 (the forward rate quoted today for an investment that begins in four years and matures in five years)?

***A.4.** Suppose you wanted to lock in an interest rate for an investment that begins in one year and matures in five years. What rate would you obtain if there are no arbitrage opportunities?

***A.5.** Suppose the yield on a one-year, zero-coupon bond is 5%. The forward rate for year 2 is 4%, and the forward rate for year 3 is 3%. What is the yield to maturity of a zero-coupon bond that matures in three years?