21. An investor paid $95 for a bond with face value $100 maturing in six months. On which day will the bond value pass $97, provided the interest rate remains constant?

22. Consider the coupon bond in Example 4.20. For any $t \in [0, 1)$, find a formula for $V(t)$. Use a graphing calculator to sketch $V(t)$ for $0 \leq t < 1$. Then, sketch the entire graph of the price of the coupon bond as a function of time, for all $t \in [0, 5]$. Finally, estimate the day on which $V(t)$ will be $105 for the first time.

23. A bond with face value 100 and annual coupons of $8 maturing after 3 years is trading at par. Find the implied continuous compounding rate.

24. The cash prices of 6-month and 1-year Treasury bills are 94.0 and 89.0. A 1.5-year bond that will pay coupons of $4 every 6 months currently sells for $94.84. A 2-year bond that will pay coupons of $5 every 6 months currently sells for $97.12. Use the bootstrap method to calculate the 6-month, 1-year, 1.5-year, and 2-year zero rates.

25. Suppose zero interest rates with continuous compounding are given by

| Maturity (years) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Rate (% per annum) | 2.0 | 3.0 | 3.7 | 4.2 | 4.6 |

    (a) Calculate forward interest rates for the second through fifth year.

    (b) Value an FRA where you will pay 5% for the third year on $1 million.

26. Portfolio A consists of a 1-year zero-coupon bond with a face value of $2,000 and a 10-year zero-coupon bond with a face value of $6,000. Portfolio B consists of a 5.95-year zero-coupon bond with a face value of $5,000. The current yield on all bonds is 10% per annum.

    (a) Show that both portfolios have the same duration.

    (b) Show that the percentage changes in the values of the two portfolios for a 0.1% per annum increase in yields are the same.

    (c) What are the percentage changes in the values of the two portfolios for a 5% per annum increase in yields?