INSTRUCTIONS TO CANDIDATES

1. This 100 point examination consists of 44 problem and essay questions. The number of points for each full question or part of a question is indicated at the beginning of the question or part. Answer these questions on the lined sheets provided in your Examination Envelope. Use dark pencil or ink. Write your Candidate ID number and the examination part, 8, at the top of each answer sheet. Your name, or any other identifying mark, must not appear.

Do not answer more than one question on a single sheet of paper. Write on only the lined side of the paper, and be careful to give the number of the question you are answering on each sheet.

The answer should be concise and confined to the question as posed. When a list of a specific size is requested, do not offer more items in your list than the number requested. For example, if you are requested to list three items, only the first three responses will be graded.

In order to receive full credit or to maximize partial credit on mathematical and computational questions, you must clearly outline your approach in either verbal or mathematical form, showing calculations where necessary.

2. Attached to the examination, after question 44, is a table of the Normal Distribution.

3. Do all problems until you reach the last page of the examination where “END OF EXAMINATION” is marked.

4. Your Examination Envelope is pre-labeled with your Candidate ID number, name, exam part, and test center. Do not remove this label. Keep a record of your Candidate ID number for future inquiries regarding this exam.

5. At the beginning of the examination, check through the exam booklet for any missing or defective pages. The supervisor has additional exams for those candidates who have defective exam booklets.

CONTINUE TO NEXT PAGE OF INSTRUCTIONS
6. **Candidates must remain in the examination center until two hours after the start of the examination.** You may leave the examination room to use the restroom with permission from the supervisor. **NEW RULE: To avoid excessive noise during the end of the examination, candidates may not leave the exam room during the last fifteen minutes of the examination.**

7. At the end of the examination, place all answer sheets in the Examination Envelope. Please insert your answer pages in your envelope in question number order. Insert a numbered page for each question, even if you have not attempted to answer that question. **BEFORE YOU TURN THE EXAMINATION ENVELOPE IN TO THE SUPERVISOR, BE SURE TO SIGN IT IN THE SPACE PROVIDED ABOVE THE CUT-OUT WINDOW.**

   Anything written in the examination booklet will not be graded. Only the answer sheets will be graded.

8. If you have brought a self-addressed, stamped envelope, you may put the examination booklet and scrap paper inside and submit it separately to the supervisor. It will be mailed to you. (Do not put the self-addressed stamped envelope inside the Examination Envelope.)

   If you do not have a self-addressed, stamped envelope, please place the examination booklet in the Examination Envelope and seal the envelope. You may not take it with you. Do not put scrap paper in the Examination Envelope. The supervisor will collect your scrap paper.

   Candidates may obtain a copy of the examination by contacting the CAS Office.

   All extra answer sheets, scrap paper, etc., must be returned to the supervisor for disposal.

9. **Candidates must not give or receive assistance of any kind during the examination.** Any cheating, any attempt to cheat, assisting others to cheat, or participating therein, or other improper conduct will result in the Casualty Actuarial Society disqualifying the candidate’s paper, and such other disciplinary action as may be deemed appropriate within the guidelines of the CAS Policy on Examination Discipline.

10. An examination survey and postage-paid reply envelope are included with the examination. No postage is necessary for surveys mailed within the United States. Candidates mailing the survey outside the United States should use the courtesy reply envelope distributed by your exam supervisor. Please complete the survey and leave it with the examination supervisor, or take the survey and envelope with you when leaving the examination center. Please submit the survey to the CAS Office by May 22, 2000. Please do not enclose the survey in the Examination Envelope.

END OF INSTRUCTIONS
1. (1 point)

Bodie, Kane, and Marcus, *Investments*, discuss various stock market indices. List two reasons why the Standard and Poor's Composite 500 provides a better representation of stock market performance than the Dow Jones Industrial Average.

2. (1 point)

According to the "Statement of Principles Regarding Property and Casualty Valuations," mismatch of asset and obligation cash flows can affect interest risk. Briefly describe how "market" risk, resulting from asset/obligation mismatch, can lead to a reduction in an insurer's future profits.
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3. (3 points)

a. (2 points)

According to Fabozzi, The Handbook of Fixed Income Securities, identify two types of risk that are material for a 5-year Treasury note but are either immaterial or nonexistent for a 3-month Treasury bill. Explain your answers.

b. (1 point)

Fabozzi, The Handbook of Fixed Income Securities, describes two types of fixed-income security risk that tend to behave in an opposite manner. Identify these two risk types and briefly describe their effect on a bond’s value during periods of increasing interest rates. Assume that the duration of the bond matches the planning horizon and that interest rates of different maturities move by equal amounts.
Answer the following question based on Bodie, Kane, and Marcus, *Investments*:

As a stock analyst, you have been asked to forecast the intrinsic value of XYZ Corporation. As of December 1, 2000, you are given the following information:

- The forecasted earnings for 2001 are $2.00 per share.
- The forecasted dividends for 2001 are $0.40 per share.
- XYZ’s return on equity is 15%.
- XYZ’s beta value is 1.25.
- The estimated market return for 2001 is 11%.
- The risk-free rate of return for 2001 is 5%.
- Dividends are paid at the end of the year.

a. (1 point)

Using a steady-state growth assumption, calculate the projected per-share dividend for 2002.

b. (1 point)

Using a steady-state growth assumption, calculate XYZ’s intrinsic value as of January 1, 2001.
5. (1 point)

A company domiciled in Europe invested in an array of international stocks for companies domiciled in Japan, Korea, Norway, and Australia. A U.S. company made an identical investment at the exact same time.

At the end of a five-year period, the European company realized an average annual return of 18%, while the U.S. company realized an average annual return of 24%. In addition, the variance of the annual returns was almost 50% higher for the U.S. company.

Explain how these differing return and variance levels can occur.

6. (2 points)

International stock indexes may be used as a benchmark for an international investment strategy. These indexes are often constructed using market capitalization levels to determine the weight applied to a given country's firms.

According to Bodie, Kane, and Marcus, Investments, list and describe two potential problems involved with using market capitalization as a weighting scheme.
7. (2 points)

Assume you have a very large pool of different stocks in which you have an opportunity to invest. You are required to invest an equal amount in each selected stock. The expected variance of returns for each stock is 6.8%. The covariance between the returns of any two stocks is 2.6%.

Determine the minimum number of different stocks that need to be purchased in order to have your portfolio variance be no more than 10% above the minimum possible portfolio variance.
8. (2 points)

Company XYZ's portfolio consists of assets A and B. These assets have the following characteristics:

- Expected return on asset A = 14.5%.
- Expected return on asset B = 12.5%.
- The standard deviation of the return on asset A = 16.5%.
- The standard deviation of the return on asset B = 14.0%.
- Short sales are not allowed.
- No riskless borrowing or lending is allowed.
- XYZ is fully invested in assets A and B.

Based on Elton and Gruber, Modern Portfolio Theory and Investment Analysis, calculate the expected portfolio return at the minimum variance level for each of the following correlation coefficients.

a. (½ point)

\[ \rho_{AB} = 1.00 \]

b. (1½ points)

\[ \rho_{AB} = 0.25 \]
Exton and Gruber, *Modern Portfolio Theory and Investment Analysis*, discuss the relationship between a company's fundamental firm variables and the Beta value of the company's stock.

For each of the following fundamental firm variables, state whether the relationship with Beta is positive or negative. Provide a brief explanation to support your answer.

a. (½ point)

   Dividend payout

b. (½ point)

   Asset size

c. (½ point)

   Leverage

d. (½ point)

   Earnings variability
You are considering four securities for an investment portfolio. You will use the single-index model, as described in Elton and Gruber, Modern Portfolio Theory and Investment Analysis, to develop an optimum portfolio.

You are given the following statistics for the securities you are considering for investment:

<table>
<thead>
<tr>
<th>Security</th>
<th>Ratio of Excess Return to Beta</th>
<th>Ratio of Beta to Unsystematic Risk</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>8</td>
<td>0.04</td>
<td>7.0</td>
</tr>
<tr>
<td>X</td>
<td>10</td>
<td>0.05</td>
<td>6.0</td>
</tr>
<tr>
<td>Y</td>
<td>5</td>
<td>0.03</td>
<td>6.2</td>
</tr>
<tr>
<td>Z</td>
<td>6</td>
<td>0.01</td>
<td>6.5</td>
</tr>
</tbody>
</table>

The C values are the candidates for the optimum portfolio’s cutoff rate.

a. (2 points)

Using the single-index model, with no short sales allowed, determine the amount of weight given to each security in the optimum portfolio.

b. (2 points)

Using the single-index model, with short sales allowed, determine the amount of weight given to each security in the optimum portfolio. Assume that the Lintner definition of short sales applies.
Elton and Gruber, *Modern Portfolio Theory and Investment Analysis*, present the following general equation for the post-tax equilibrium Capital Asset Pricing Model:

\[ E(R_i) = R_F + \beta_i[(E(R_M) - R_F) - \tau(\delta_M - R_F)] + \tau(\delta_i - R_F), \]

where:
- \( R_F \) = risk-free rate
- \( \beta_i \) = Beta for asset \( i \)
- \( E(R_M) \) = Expected market return
- \( \tau \) = a tax factor that measures the relevant market tax rates on capital gains and income
- \( \delta_M \) = the dividend yield of the market portfolio
- \( \delta_i \) = the dividend yield for asset \( i \)

For a given market, the post-tax equilibrium Capital Asset Pricing Model is represented by the following equation:

\[ E(R_i) = 0.045 + 0.05\beta_i + 0.25\delta_i \]

Calculate the risk-free rate underlying this model.
12. (3½ points)

According to Bodie, Kane, and Marcus, Investments, the following second-pass
regression equation can be used to empirically test the validity of the Capital Asset
Pricing Model:

\[ r_i - r_f = \gamma_0 + \gamma_1 \mu_i + \gamma_2 \sigma^2 (e_i) \]

a. (2½ points)

What are the regression coefficients \( \gamma_0 \), \( \gamma_1 \), and \( \gamma_2 \) if CAPM is valid? Explain your answer.

b. (1 point)

Early tests completed by researchers, using the above regression equation,
seemed to reject the CAPM. However, Bodie, Kane, and Marcus express
several concerns about the validity of the tests.

Identify and explain one of the authors’ concerns.
13. (2 points)

Answer the following based on the discussion of Arbitrage Pricing Theory (APT) in Elton and Gruber, Modern Portfolio Theory and Investment Analysis.

The following three portfolios are observed:

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Expected Return (%)</th>
<th>$b_{11}$</th>
<th>$b_{12}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>1.25</td>
<td>2.00</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>1.00</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Where $b_{ij}$ is the sensitivity of portfolio $i$'s return to the $j$th index.

The equation of the plane satisfied by these three portfolios is $R_i = 8 + 4b_{11} + 2b_{12}$.

Assume a new portfolio 4 becomes available, with an expected return of 14%, and with $b_{11}$ and $b_{12}$ both equal to 0.75.

Briefly describe an arbitrage opportunity that exists with the introduction of this new portfolio.
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14. (4 points)

You are given the following information about a bond:

- The term-to-maturity is 2 years.
- The bond has a 9% annual coupon rate, paid semiannually.
- The annual bond-equivalent yield-to-maturity is 8%.
- The par value is $100.

Using the definitions provided in Fabozzi, *The Handbook of Fixed Income Securities*, answer the following:

a. (½ point)

Calculate the current price of the bond.

b. (1 point)

Calculate the Macaulay Duration of the bond.

c. (1 point)

Calculate the convexity of the bond.

d. (1½ points)

Fabozzi presents a method of using modified duration and convexity to approximate the price change for a bond for a given change in yield.

For a 200 basis point increase in yield, determine the amount of error in using duration and convexity to estimate the price change.

CONTINUED ON NEXT PAGE

12
15. (3 points)

You are considering the purchase of a 30-year bond with the following characteristics:

- The annual coupon rate is 5.5%, payable semiannually.
- The annual bond-equivalent yield-to-maturity is 6.25%.
- The annual bond-equivalent reinvestment rate is 6.5%.

Your investment horizon is 5 years. The expected annual bond-equivalent yield-to-maturity on 25-year bonds at the end of the investment horizon is 5%.

Based on Fabozzi, The Handbook of Fixed Income Securities, calculate the total return on an effective annual rate basis for this bond purchase over the 5-year investment horizon.
16. (2 points)

Assets A, B, and C have identical levels of risk. The asset prices, as of January 1, 2000, are as follows:

<table>
<thead>
<tr>
<th>Asset</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$90.70</td>
</tr>
<tr>
<td>B</td>
<td>$105.69</td>
</tr>
<tr>
<td>C</td>
<td>$97.53</td>
</tr>
</tbody>
</table>

The entire cash flow returns for the assets are as follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$100.00</td>
<td>$108.00</td>
<td>$105.00</td>
</tr>
<tr>
<td>B</td>
<td>$8.00</td>
<td>$108.00</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>$5.00</td>
<td>$5.00</td>
<td></td>
</tr>
</tbody>
</table>

Assume that the "law of one price", as defined in Elton and Gruber, Modern Portfolio Theory and Investment Analysis, is applicable.

Calculate the annual bond-equivalent spot rates $S_{01}$, $S_{02}$, and $S_{03}$. 

CONTINUED ON NEXT PAGE
17. (2 points)

Based on Fabozzi, *The Handbook of Fixed Income Securities*, answer the following:

a. (1 point)

Briefly describe two problems associated with using yield-to-maturity to measure the potential return from investing in a bond.

b. (1 point)

Briefly describe two problems associated with using yield-to-call to measure the potential return from investing in a bond.

18. (2 points) Used in FM Manual

Based on Fabozzi, *The Handbook of Fixed Income Securities*, answer the following:

a. (½ point)

A Treasury bill with 75 days to maturity has a face value of $50,000. If this bill is selling for $49,400, what is the yield on a bank discount basis?

b. (½ point)

What is the CD-equivalent yield for the Treasury bill shown in part a. above?

c. (1 point)

List two reasons why the quoted yield on a bank discount basis is not a meaningful measure for returns on Treasury bills.
19. (2 points)

A portfolio manager is considering two types of mortgage derivative products for investment: interest-only strips and principal-only strips. While most forecasters are projecting level interest rates, the portfolio manager believes that interest rates will fall in the near future.

Explain which of the two derivatives the portfolio manager should invest in.

20. (2 points)

The value of a population of bonds is $200,000 as of January 1, 1997. Assume that individual bonds can exit this population by means of default, calls and maturity only.

You are given the following information about the population:

<table>
<thead>
<tr>
<th></th>
<th>1997</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of defaulting debt during year</td>
<td>$10,000</td>
<td>$15,000</td>
</tr>
<tr>
<td>Value of bonds called during year</td>
<td>$ 5,000</td>
<td>$ 6,000</td>
</tr>
<tr>
<td>Value of bonds maturing during year</td>
<td>$ 2,500</td>
<td>$ 2,000</td>
</tr>
<tr>
<td>Average price of defaulting debt during year</td>
<td>$ 3,500</td>
<td>$ 4,500</td>
</tr>
</tbody>
</table>

Based on Altman, “Measuring Corporate Bond Mortality and Performance,” calculate the cumulative mortality rate as of December 31, 1998 for this population of bonds.
21. (3 points)

Based on the discussion of defined benefit plans in Bodie, Kane, and Marcus, *Investments*, answer the following.

a. (1 point)

Two measures of defined benefit pension liabilities are the accumulated benefit obligation (ABO) and the projected benefit obligation (PBO).

For a United States defined benefit plan, which liability measure do the authors believe is the more appropriate target to hedge against in an investment strategy? Explain your answer.

b. (1 point)

Which liability measure (ABO or PBO) would be more useful to a financial analyst in determining the going-concern value of a company? Explain your answer.

c. (1 point)

Identify one reason why the sponsor of an underfunded defined benefit plan of a corporation in financial distress would consider an extremely high-risk investment strategy.
22. (1 point)

A company knows that it will purchase 2 million barrels of crude oil in 6 months. The company purchases 3,300 6-month futures contracts on crude oil.

You are given the following information:

- The company uses the optimal hedge ratio.
- The standard deviation of the change in the futures price for the 6-month period is 0.25.
- The coefficient of correlation between the 6-month change in the price of crude oil and the 6-month change in the futures price is 0.75.
- One crude oil futures contract is on 1,000 barrels.

Based on Hull, Options, Futures, and Other Derivatives, determine the standard deviation of the change in the spot price over the 6-month period.
23. (2 points)

You are given the following information:

- The current price of Lucent Technologies is $60 per share.
- The two-year forward price is $69.
- For the two-year period, the risk-free rate is a constant annual 5.5%, compounded continuously.
- The stock pays no dividends.

Based on Hull, Options, Futures, and Other Derivatives, answer the following:

a. (1 point)

Describe an arbitrage strategy that will lead to a risk-free payoff.

b. (1 point)

For the strategy described in part a. above, determine the amount of the payoff at the end of two years.

24. (1 point)

You are given the following:

- The risk-free rate is a constant annual 8%, compounded continuously.
- The three-month futures price for an asset is $400.
- Dividends on the asset are paid continuously at a constant dividend-yield rate, q, of 2.4% per annum.

Based on Hull, Options, Futures, and Other Derivatives, what is the current price for the asset, assuming no arbitrage opportunity?

CONTINUED ON NEXT PAGE
25. (1 point)

There is an outstanding call option to buy 100 shares of a company with a strike price of $20. The company then declares a 10% stock dividend.

Based on Hull, Options, Futures, & Other Derivatives, answer the following:

a. (½ point)

   Calculate the number of shares the option holder would have the right to purchase after the stock dividend.

b. (½ point)

   Calculate the new strike price of the call option after the stock dividend.
26. (3 points)

You are given the following:

- Stock Price = $50.
- The risk-free interest rate is a constant annual 8%, compounded continuously.
- The price of a 6-month European call option with an exercise price of $48 is $5.
- The price of a 6-month European put option with an exercise price of $48 is $3.
- Assume no transaction costs and that the stock pays no dividends.

Based on Hull, *Options, Futures, & Other Derivatives*, answer the following:

a. (1½ points)

Using the put-call parity relationship, demonstrate that an arbitrage opportunity exists.

b. (1 point)

Using stock, puts, & calls, describe what one would buy, sell, or short to take advantage of the arbitrage opportunity.

c. (½ point)

Calculate the per-share profit that can be made at the time the options expire by implementing the strategy that you recommend in part b. above.
27. (3 points)

Based on the description of combination option trading strategies in Hull, Options, Futures, and Other Derivatives, answer the following:

a. (1½ points)

For a straddle combination, describe:

i) The trades involved

ii) The initial investment that accompanies implementation of the strategy

iii) The stock price movement that will lead to a profit for the investor

b. (1½ points)

For a strangle combination, describe:

i) The trades involved

ii) The initial investment that accompanies implementation of the strategy

iii) The stock price movement that will lead to a profit for the investor
28. (3 points)

An investor, wishing to insure herself against a decrease in the value of her stock without incurring the total cost of buying a European put option, makes use of a "collar" strategy, whereby she sells a European call option and uses the proceeds to purchase a put option.

Assume the following:

- Stock prices change quarterly.
- The option matures in six months.
- The current stock price is $50.
- The call option strike price is $60.
- The put option strike price is $45.
- Each quarter, the stock price will either increase or decrease by 20%.
- The risk-free interest rate is 5% per annum, compounded continuously.

Based on Hull, *Options, Futures, and Other Derivatives*, determine the investor's initial net cost or gain from selling the call and buying the put.

29. (2½ points)

A company's cash position (in $millions) follows a generalized Wiener process with a variance rate of 4.0 per quarter. With an initial position of $2.28 million at the beginning of the year, there is a 14.23% probability that the company will find itself in a negative cash position at the end of the year.

According to Hull, *Options, Futures, and Other Derivatives*, solve for the drift rate per quarter.
30. (2 points)

You are given the following information about a European call option.

- The current stock price is $35.
- The exercise price is $40.
- The option matures in 6 months.
- The expected return, $\mu$, on the stock is 18% per annum.
- The volatility, $\sigma$, of the stock price is 24% per annum.
- The stock’s price at each future time $T$, given its current price, is lognormally distributed.
- The stock pays no dividends.

According to Hull, Options, Futures, and Other Derivatives, what is the probability that the call option will be exercised?

Used in rewritten version in FM Manual, problem 7 practice exam 17

31. (3 points)

You are considering the purchase of a three-month European put option on a stock with an announced dividend payment of $1.50 in two months.

You are given the following information:

- The strike price is $50.
- The risk-free interest rate is a constant annual 10%, compounded continuously.
- The volatility of the stock price is 30% per annum.

Using the Black-Scholes pricing formulas presented in Hull, Options, Futures, and Other Derivatives, and a value of $-0.1086$ for $d_2$, calculate the current share price.
You are given the following partially completed annual binomial table.

According to Fabozzi, *The Handbook of Fixed income Securities*, calculate the value of the bond if it is putable at par ($50) in years one and two.
33. (2 points)

"Dynamic Financial Models of Property/Casualty Insurers," by the CAS Subcommittee on Dynamic Financial Models, identifies four major categories of risk (labeled as C-1 through C-4) applicable to the property/casualty industry.

Assume that there is a sudden, unexpected surge in both inflation and interest rates. For each of the four risk categories, provide an example of how this surge could adversely impact a P&C insurer.

34. (3 points)

Based on the discussion of interest rate simulation in D'Arcy et al., "Building a Public Access PC-Based DFA Model," answer the following:

a. (1 point)

The interest rate simulation process in the public access model has two components, one a deterministic factor and the other a random factor.

Briefly describe what is modeled by the deterministic factor.

b. (1 point)

Briefly describe how the model generates the inflation rate from the simulated interest rate.

c. (1 point)

Identify two reasons why the degree of accuracy of the generated interest rate is less critical for P&C insurers as opposed to life insurers.
35. (2 points)


a. (1 point)

One of the principles discusses how the results of the analysis should be presented to management.

Identify how the authors suggest that results should be presented. Also provide the reasoning behind this suggestion.

b. (1 point)

One of the principles discusses three risks inherent in the DFA model itself.

Identify and briefly describe two of these three risks.

36. (1 point)

According to Lowe and Stanard, “An Integrated Dynamic Financial Analysis and Decision Support System for a Property Catastrophe Reinsurer,” parameter risk is not explicitly included within the liability scenario generator. Instead, the parameters are sensitivity tested.

Briefly describe the two forms of sensitivity tests identified by Lowe and Stanard.
37. (2 points)

In “An Integrated Dynamic Financial Analysis and Decision Support System for a Property Catastrophe Reinsurer,” Lowe and Stanard discuss three basic risk classifications that must be considered in a dynamic financial analysis model.

Consider the following two companies:

- ABC Insurance Company is a direct auto insurer operating in the United States.
- XYZ Reinsurance Company provides property catastrophe reinsurance on a worldwide basis.

a. (½ point)

In pricing insurance products, identify one business risk that would be more significant for ABC as opposed to XYZ.

b. (½ point)

Other than the highly unpredictable nature of catastrophe claim events, identify one liability risk faced by XYZ that is minimal for ABC.

c. (½ point)

According to Lowe and Stanard, why is the standard deviation often criticized as a risk measure for P&C insurers?

d. (½ point)

List two alternative measures of risk identified by Lowe and Stanard.
Based on Correnti, Sonlin, and Isaac, "Applying a DFA Model to Improve Strategic Business Decisions," answer the following:

You are considering three separate variables labeled Liabilities, Capital Market, and Discount Rates in an integrated risk management model. You are given the following table of "runs" from the model to complete a decomposition of risk analysis.

<table>
<thead>
<tr>
<th>Scenario A</th>
<th>Run</th>
<th>Liabilities</th>
<th>Capital Market</th>
<th>Discount Rates</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>S</td>
<td>D</td>
<td>D</td>
<td>20,000</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>D</td>
<td>S</td>
<td>S</td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td></td>
</tr>
</tbody>
</table>

S indicates that the risk component is allowed to vary in the model run. D indicates that the variable is held constant.

a. (1½ points)

Explain what is measured in each of the three model runs.

b. (1 point)

Assume that the correlation coefficient between Capital Market and Discount Rates Combined and Liabilities is -0.05.

Calculate the total economic risk to the company for the portfolio underlying the table above.

c. (½ point)

Calculate the portion of the insurer's total economic risk in Scenario A that is due to its asset allocation and investment strategy.
39. (3 points)

Based on Feldblum, "Asset Liability Matching for Property/Casualty Insurers," answer the following:

a. (1 point)

According to Feldblum, why are interest rate changes not a serious risk for stable property/casualty insurers?

b. (2 points)

Feldblum discusses how a property/casualty insurer should divide its assets among several types of investments.

For a P&C insurer, identify one advantage and one disadvantage for holding each of the following investments.

i. Long-term bonds
ii. Common stocks
iii. Commercial paper or Treasury bills
iv. Real estate
Company XYZ has the following assets and liabilities:

<table>
<thead>
<tr>
<th>Assets</th>
<th>Market Value</th>
<th>Duration (years)</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Based on Noris, "Asset/Liability Management Strategies for Property and Casualty Companies," answer the following:

a. (1 point)

Calculate the Duration Gap of Surplus.

b. (½ point)

Calculate the Duration Gap for Economic Leverage.

c. (½ point)

The stock duration shown in the table above was determined by using an approximation identified by Noris.

Why does this approximation often produce unrealistic values?
41. (2 points)

Based on Fabozzi, *The Handbook of Fixed income Securities*, answer the following:

A bond is issued on January 1, 2000, with $100 annual coupon payments and a $1,000 principal repayment on January 1, 2003.

If the yield-to-maturity is 9%, calculate the dispersion ($M^2$) for the bond as of January 1, 2000.

42. (2 points)

Based on Miccolis, "An Investigation of Methods, Assumptions, and Risk Modeling for the Valuation of Property/Casualty Insurance Companies," answer the following:

a. (1 point)

You have been asked to build a DFA model for a property/casualty insurance company. In determining the value of future earnings, describe the two properties that the discount rate should possess.

b. (1 point)

The cost of capital generally must be reflected in determining the economic value of an insurance company. Describe one circumstance cited by Miccolis in which the economic value can be appropriately calculated with a zero cost of capital component.
Based on Fabozzi, *The Handbook of Fixed income Securities*, answer the following:

a. (1 point)

For single-period immunization, explain why a bullet maturity structure is generally preferred to an even ladder strategy.

For parts b. and c. below, assume that an insurer currently uses duration matching to cover on-going claim liabilities. The insurer is evaluating the merits of switching to a dedicated bond portfolio.

b. (½ point)

Describe one advantage of switching to a dedicated bond portfolio.

c. (½ point)

Describe one disadvantage of switching to a dedicated bond portfolio.
You are given the following information for a property insurer:

- Asset values are uniformly distributed at the end of the experience period from $15,000 to $25,000.
- Incurred Losses are distributed at the end of the experience period according to the following table:

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<tr>
<th>Incurred Loss</th>
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<td>0.55</td>
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<tr>
<td>$25,000</td>
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</table>

- Asset values and incurred losses are independent.
- Premiums collected will be converted to risk-free assets with no variability in their values.
- There are no expenses.
- There is no investment income.

a. (2 points)
Based on Butsic, “Solvency Measurement for Property-Liability Risk-Based Capital Applications,” determine how much additional fixed asset (premium) must be provided to yield an expected policyholder deficit to expected loss (EPD) ratio of 0.01 (Ignore discounting).

b. (2 points)
Assume that:

- \( W = \text{Assets (A)} - \text{Liabilities (L)} \)

Based on the variability of the incurred losses and the expected asset value as defined in part a. above, derive the value at risk (VAR) at the 95 percent confidence level consistent with “Risk 2: Measuring the Risk in Value at Risk” by Jorion. Do not include the additional asset derived in part a. above.
The Normal Distribution

\[ \Pr(X \leq x) = \Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{t^2}{2}} \, dt \]

[hundredths]

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</table>
1. (1 point)

(1) The S&P 500 is a more broadly based index.
(2) The S&P 500 is a market value weighted index, so actual market capitalization influences overall changes. The DJIA does not reflect the varying equity level of individual stocks.

2. (1 point)

“If an excess of required disbursements over receipts develops, the risk bearer may have to borrow or liquidate assets with yields below then current market rates to make up the difference. Borrowing at a relatively high interest rate, or inability to invest the difference at then current market rates produces a reduction in the risk bearer’s future profits.”
3. (3 points)

a. (2 points)

**Market or Interest Rate Risk:** The risk to an investor, who sells a fixed income security before the maturity date, of realizing a capital loss due to an increase in interest rates between the time the security was purchased and the time the security was sold. This risk is minimal for the Treasury Bill due to the very short duration of this security. The risk is material for a 5 year Treasury Note due to its longer duration.

**Reinvestment Risk:** The risk to an investor is that the interest rate at which interim cash flows from a fixed income security can be reinvested will decrease from levels available at the time the security was purchased. The risk is zero for the Treasury Bill because Treasury Bills are purchased at a discount and are paid at face value at maturity. The risk is material for a five year Treasury Note because Treasury Notes provide semi-annual interest payments.

**Inflation or Purchasing Power Risk:** The risk to an investor is that greater than expected inflation decreases the purchasing power of the cash flows from a fixed income security. The risk is immaterial for the Treasury Bill due to the very short duration of this instrument. The risk is material for the Treasury Note due to its five year duration.

b. (1 point)

**Market or Interest Rate Risk and Reinvestment Risk** tend to offset one another. Interest Rate Risk is the risk that an increase in interest rates prior to maturity of a fixed income security will cause the market value to decrease. Reinvestment Risk is the risk that a decrease in interest rates prior to maturity of a fixed income security will decrease the investment income that may be earned on interim cash flows. Therefore, an increase in interest rates increases the effect of interest rate risk, but decreases the effect of reinvestment risk.
4. (2 points)

a. (1 point)

\[ b = \text{plowback rate} = 1.0 - \frac{\text{forecasted dividend rate}}{\text{forecasted earnings per share}} = 1.0 - \frac{0.40}{2.00} = 0.80 \]

\[ g = (\text{ROE}) \times (\text{plowback rate}) = 0.15 \times 0.80 = 0.12 \]

\[ D_{2001} = 0.40 \]
\[ D_{2002} = 0.40 \times 1.12 = 0.45 \]

b. (1 point)

Under the steady-state growth assumption, the intrinsic value is calculated as follows:

\[ V_x = \frac{D_{x+1}}{(k-g)} \]

From CAPM \[ k = r_f + \beta (E(r_m) - r_f) = 0.05 + (1.25) \times (0.11 - 0.05) = 0.125 \]

\[ V_{2000} = \frac{D_{2001}}{(k-g)} = \frac{0.40}{0.125 - 0.12} = \$80 \]

5. (1 point)

The U.S. company earns a higher return because the U.S. has a higher currency exchange gain than the European company. The U.S. return variation is greater than the European’s because the U.S. currency (in comparison to the currencies of the investment portfolio countries) fluctuates to a larger degree than the European company’s currency.
6. (2 points)

1. Different countries have different proportions of their corporate sector organized as publicly traded firms. Therefore, market value of equity may not accurately represent a given country's importance in the total international economy. The authors indicate that a diversified portfolio should purchase shares for a country based on that country's broad asset base (relative to the total asset base). The authors indicate that GDP may be a better measure.

2. Cross-holding tends to overstate the aggregate value of outstanding equity. Cross-holdings refer to equity investments that firms make in other firms. To accurately measure the productive assets of a given country, inter-corporate holdings must be netted out to avoid double-counting.

7. (2 points)

Let \( N = \# \) of different stocks purchased. As \( N \) approaches \( \infty \), the portfolio variance approaches the average covariance. This is the minimum variance level.

\[
\sigma_p^2 = \frac{1}{N} \left( \sigma_j^2 - \sigma_{jk} \right) + \sigma_{jk} \quad \text{(also } = \sigma_j^2/N + \sigma_{jk}(N-1)/N \text{)} \]

\[
(1/N)(6.8 - 2.6) + 2.6 \leq (1.1)(2.6)
\]

\[
(1/N)(4.2) + 2.6 \leq 2.86
\]

\[
(1/N)(4.2) \leq 0.26
\]

\[
N \ (4.2)/(0.26) \geq 16.15
\]

Therefore, 17 stocks are required.
8. (2 points)

a. (½ point)

When assets are perfectly correlated, there is no benefit to diversification. In order to achieve minimum variance, the total amount should be invested in the asset with lower risk. Therefore, 100% invested in Asset B and Portfolio Return = 12.5%.

b. (1½ points)

\[ X_A = \frac{\sigma_A^2 - \sigma_A \sigma_{AB} \rho_{AB}}{\sigma_A^2 + \sigma_B^2 - 2 \sigma_A \sigma_B \rho_{AB}} = \frac{[.14^2 - (.165)(.14)(.25)]}{[.165^2 + (.14)^2 - 2(.165)(.14)(.25)]} = 0.39 \]

\[ X_B = 1 - 0.39 = 0.61 \]

Portfolio Return = \((0.39)(.145) + (0.61)(.125) = .1328 \text{ or } 13.28\%\)

9. (2 points)

a. (½ point)

Negative relationship to \(\beta\)

Management is more reluctant to cut dividends than raise them, thus high payment is indicative of confidence in future earnings, or

Dividend payments are less risky than capital gains, thus the company that pays more of its earnings in dividends is less risky.

b. (½ point)

Negative relationship to \(\beta\)

Large firms are thought to be less risky, partially because they have better access to capital markets.

(Question 9 Continued on next page)
(Question 9 Continued)

c. (½ point)

Positive relationship to $\beta$

Leverage tends to increase the volatility of the earnings stream

d. (½ point)

Positive relationship to $\beta$

The more variable a company's earning stream, the more risk associated with the stock, leading to a higher $\beta$ value.
10. (4 points)

a. (2 points)

Step 1: In order to determine $C^*$, rank the securities according to the ratio of excess return to Beta

<table>
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<th>Security</th>
<th>Ratio of Excess Return to Beta</th>
<th>Ratio of Beta to Unsystematic Risk</th>
<th>$C^*$</th>
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$C^* = 7$, and securities $X$ and $W$ are included in the optimum portfolio.

Step 2: Determine the $Z$ values

$Z_j = (\text{Ratio of Beta to Unsystematic Risk}) \times [(\text{Ratio of Excess Return to Beta}) - C^*]$

- $Z_X = (0.05) \times (10-7) = 0.15$
- $Z_W = (0.04) \times (8-7) = 0.04$

Step 3: Determine the weights ($X_j$'s)

- $X_X = \text{weight given to security } X = 0.15 / (0.04 + 0.15) = 0.789$
- $X_W = \text{weight given to security } W = 1 - X_B = 0.211$

Obviously, securities $Y$ and $Z$ have weights of zero.

b. (2 points)

With short-sales allowed, all securities are included in the optimum portfolio. Therefore, $C^*=6.2$.

Step 1: Use the same formula as above to determine the $Z$ values

- $Z_X = (0.05) \times (10-6.2) = 0.19$
- $Z_W = (0.04) \times (8-6.2) = 0.072$
- $Z_Z = (0.01) \times (6-6.2) = -0.002$
- $Z_Y = (0.03) \times (5-6.2) = -0.036$

Step 2: Determine the weights using the Lintner definition of short sales

$X_i = Z_i / \sum |Z_j|$

$\sum |Z_j| = |Z_X| + |Z_W| + |Z_Z| + |Z_Y| = 0.19 + 0.072 + 0.002 + 0.036 = 0.30$

- $X_X = \text{weight given to security } X = 0.19 / 0.30 = 0.63$
- $X_W = \text{weight given to security } W = 0.072 / 0.30 = 0.24$
- $X_Z = \text{weight given to security } Z = -0.002 / 0.30 = -0.0067$
- $X_Y = \text{weight given to security } Y = -0.036 / 0.30 = -0.12$
11. (2 points)

For a risk-free asset, $\beta_i = 0$.

Substitute into the general equation:
$$E(R_i) = R_F + \beta_i[(E(R_M) - R_F) - \tau(\delta_M - R_F)] + \tau(\delta_i - R_F)$$
$$E(R_F) = R_F + 0[(E(R_M) - R_F) - \tau(\delta_M - R_F)] + \tau(\delta_F - R_F).$$

Since $E(R_F) = R_F$, the above equation can only be satisfied if $\delta_F = R_F$.

Substitute $R_F$ for $\delta_F$ in the simplified equation:
$$E(R_F) = 0.045 + 0.05(0) + 0.25R_F$$
$$R_F = 0.045 + 0.05(0) + 0.25R_F$$
$$0.75R_F = 0.045$$
$$R_F = 0.06$$

12. (3½ points)

a. (2½ points)

$\gamma_0 = 0, \gamma_1 = \overline{r_m - r_f},$ and $\gamma_2 = 0$

According to CAPM, the excess return on a security $(r_i - r_f)$ depends only on systematic risk, as measured by beta ($\beta_i$). The excess return should be independent of nonsystematic risk $(\sigma^2(e_i))$ or any other factor; therefore, $\gamma_2$ and $\gamma_0$ must be insignificantly different from zero.

b. (1 point)

1. Stock returns are extremely volatile, which lessens the precision of tests of average return.

2. The market index used in the tests is not the ‘market portfolio’ of the CAPM.

3. In light of the asset volatility, the security betas from the first stage regressions are necessarily estimated with substantial sampling error and therefore can not readily be used as inputs to the second-stage regression.

4. Investors can not borrow at the risk free rate, as assumed by the simple version of the CAPM.
13. (2 points)

Combine 50% of Portfolio 1 with 50% of Portfolio 3 to produce a new portfolio 5. This new portfolio has an expected return of 12.5% and risk factors of $b_1$ and $b_2$ both equal to 0.75. Portfolio 5 has the same risk level as Portfolio 4, but has a lower return. Therefore, an arbitrage opportunity exists.

Arbitragers could sell Portfolio 5 short in order to buy Portfolio 4, which would guarantee a profit with no investment cost and no risk.

14. (4 points)

a. (% point)

\[ C = \text{coupon amount} = \$4.50 \]
\[ n = \# \text{ of periods until maturity} = 4 \]
\[ M = \text{par value} = 100 \]
\[ i = \text{yield rate} = .04 \]
\[ v = 1/(1+i) \]

Price = \( C \left[ \frac{(1-v^n)}{i} \right] + Mv^n \) = \( (4.5) \left[ \frac{(1-1.04^{-4})}{.04} \right] + 100 \left[ (1.04^{-4}) \right] = \$101.81 \)

b. (1 point)

<table>
<thead>
<tr>
<th>Time t</th>
<th>CF</th>
<th>PVCF</th>
<th>PVCF x t</th>
<th>PVCF x t x (t+1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.5</td>
<td>4.327</td>
<td>4.327</td>
<td>8.654</td>
</tr>
<tr>
<td>2</td>
<td>4.5</td>
<td>4.161</td>
<td>8.322</td>
<td>24.966</td>
</tr>
<tr>
<td>3</td>
<td>4.5</td>
<td>4.000</td>
<td>12.000</td>
<td>48.000</td>
</tr>
<tr>
<td>4</td>
<td>104.5</td>
<td>89.327</td>
<td>357.308</td>
<td>17,866.540</td>
</tr>
</tbody>
</table>

Tot. 101.815 | 381.957 | 1,868.160

Duration = \( 381.957 / (2 \times 101.815) \) = 1.87574

(NOTE: The student could also use this table to produce the answer for Part a)

c. (1 point)

From table above:

\[ \text{Convexity} = \frac{1}{1.04^2} \times 1,868.16 / (2 \times 101.815) = 4.241072 \]

(NOTE: The student could use the following slightly modification to the convexity formula: \( t^2 \) rather than \( t(t+1) \). This is an acceptable response)

(Question 14 continued on next page)
d. (1½ points)

Modified Duration = 1.87574/1.04 = 1.8036

Est. Percentage Price Change = -Modified Duration x Yield Change x 100
+ 0.5 x Convexity x (Yield Change)² x 100
= -(1.8036 x 0.02 x 100) + (0.5 x 4.241072 x (0.02)² x 100)
= -3.6072% + .0084821%
= -3.52238% price change estimate

Est. Revised Bond Price = $101.815 x (100% - 3.52238%) = $98.23

Actual Revised Bond Price = $4.50 x [(1 - 1.05⁻⁴)/.05] + 100 x (1.05⁻⁴) = $98.23
Therefore, there is no error in the estimate (subject to some rounding differences)

15. (3 points)

Assume the par value of the bond is $1,000

Price of Bond using current yield = (27.5)x[(1 - 1.03125⁻⁶⁰)/.03125] + 1,000x (1.03125⁻⁶⁰)
= $898.94

Coupons plus interest-on-interest for investment horizon = 27.50 x [(1.0325⁻¹⁰)-1] / .0325
= $318.91

Price of Bond at end of investment horizon
= (27.5)x[(1 - 1.025⁻⁵⁰)/.025] + 1,000x (1.025⁻⁵⁰) = $1,070.91

Total $ return for 5 year period = $318.91 + $1,070.91 = $1,389.82

Effective Annual Return = (1389.82/898.94)⁰.² - 1.0 = 0.091 or 9.1%.
16. (2 points)

Solve for $S_{02}$ first using bond A
$$90.70 = \frac{100}{(1 + S_{02}/2)^2}$$
$S_{02} = 10\%$

Then solve for $S_{01}$ using result above and bond B
$$105.69 = \frac{8}{(1 + S_{01}/2)} + \frac{108}{(1 + S_{02}/2)^2}$$
$S_{01} = 7\%$

Then solve for $S_{03}$ using above and bond C
$$97.53 = 5/(1 + S_{01}/2) + 5/(1 + S_{02}/2)^2 + 105/(1 + S_{03}/2)^3$$
$S_{03} = 12\%$

17. (2 points)

a. (1 point)

(1) YTM assumes that coupon payments can be reinvested at the YTM rate. This may or may not be the case.

(2) YTM assumes that the bond is held to maturity. If not held to maturity, the actual return may vary from the YTM.

b. (1 point)

(1) Yield-to-call assumes that coupon payments can be reinvested at the same rate. This may or may not be the case.

(2) Yield-to-call assumes that the investor will hold the bond to the assumed call date and that the issuer will call the bond on that date.

(3) If the investment horizon is longer than the first call date, yield-to-call does not reflect how the investor will reinvest the proceeds if the bond is called.
18. (2 points)

a. (½ point)

\[ Y_d = \text{yield on a bank discount basis} \]
\[ = \frac{D-F}{F} \times \frac{360}{t} \]
\[ = \left[ \frac{50,000 - 49,400}{50,000} \right] \times \frac{360}{75} = 0.0576 \text{ or } 5.76\% \]

b. (½ point)

\[ \text{CD equivalent yield} = \frac{360 \times Y_d}{360 - (t \times Y_d)} \]
\[ = \frac{360 \times 0.0576}{360 - (75 \times 0.0576)} = 0.0583 \text{ or } 5.83\% \]

c. (1 point)

(1) The measure is based on a face-value investment rather than the actual dollar amount invested.

(2) The yield is annualized using a 360-day year rather than 365 days, making it difficult to compare with T-bills and treasury bonds.

19. (2 points)

The portfolio manager should invest in principal-only (PO) strips.

If interest rates fall, mortgage pre-payments will accelerate. PO investors will receive their payments earlier than anticipated. The present value of these actual principal payments will be larger than the assumed present-value underlying the investment price at the time of purchase.

Conversely, interest-only (IO) strips will fall in value if interest rates drop. With increased mortgage pre-payments, there will be a drop-off in the interest payments.
20. (2 points)

\[
CMR_{1998} = 1 - [(1 - MMR_{1997}) \times (1 - MMR_{1998})]
\]

\[
MMR_t = \frac{\text{total value of defaulting debt in year } t}{\text{total value of population of bonds at beginning of year } t}
\]

\[
MMR_{1997} = \frac{10,000}{200,000} = 0.05
\]
\[
MMR_{1998} = \frac{15,000}{(200,000 - 10,000 - 5,000 - 2,500)} = 0.082192
\]
\[
CMR_{1999} = 1 - (1 - 0.05) \times (1 - 0.082192) = 0.1280824
\]

21. (3 points)

a. (1 point)

The ABO is the appropriate target because it represents the company's current contractual obligation to employees. It is also the amount required to be reported as a liability by FASB. The PBO includes projected salary increases that may or may not be realized.

b. (1 point)

The PBO would be more useful, as it would allow the analyst to develop an appropriate estimate of future labor cost cash flows.

c. (1 point)

Pension insurance (PBGC) protects beneficiaries who work for financially distressed companies. The distressed company may want to invest in the riskiest assets in order to maximize return and hold down benefit costs.
22. (1 point)

\[ h = \text{the optimal hedge ratio} \]
\[ \rho = \text{coefficient of correlation between } \Delta S \text{ and } \Delta F \]
\[ \sigma_S = \text{standard deviation of } \Delta S, \text{ the change in the spot price} \]
\[ \sigma_F = \text{standard deviation of } \Delta F, \text{ the change in the futures price} \]

3,300 futures = 3.3 million barrels
3.3 million barrels ÷ 2.0 million barrels = 1.65 = h
\[ \rho = 0.75, \quad \sigma_F = 0.25 \]

\[ \sigma_S = \frac{h \sigma_F}{\rho} \]

\[ \sigma_S = 1.65 \times 0.25 \div 0.75 = 0.55 \]

23. (2 points)

(a. (1 point)

Arbitrage strategy:
- Borrow for two years at the risk-free rate
- Use the borrowed funds to buy shares of Lucent at $60
- Take a short position on the two-year forward contract to sell the number of Lucent shares purchased.

(b. (1 point)

\[ F_0 = S_0 \times e^{rT} \]

\[ F_0 = \text{The forward price today} = \$69 \]
\[ S_0 = \text{The spot price of the asset (stock) underlying the forward contract} = \$60 \]
\[ r = \text{The risk-free interest per annum, with continuous compounding, for an investment maturing at time } T. \quad r = 5.50\%, \quad T = 2. \]

Profit = Actual Forward price – \( F_0 = \$69 - \$66.98 = \$2.02 \text{ per share.} \]
24. (1 point)

\[ F_0 = S_0 \cdot e^{(r-q)T} \]

\( F_0 \) = The forward price today = $400
\( S_0 \) = The spot price of the asset (stock) underlying the forward contract
\( r \) = The risk-free interest per annum, with continuous compounding, for an investment maturing at time \( T \).
\( r = 8.00\% \)
\( T = 0.25 \).
\( q \) = The expected dividend yield at a continuous rate

\[ S_0 = 400 \cdot e^{-0.08 \cdot 0.24} \cdot 0.25 = 394.44 \]

25. (1 point)

a. (½ point)

10% dividend equals an 11 to 10 stock split.
The new contract would be for 100 * 1.10 = 110 shares

b. (½ point)

The price would decrease by 10/11 = .909
$20 * .909 = $18.18
26. (3 points)

a. (1½ points)

Equation (7.3): \( c + X e^{-rT} = p + S_0 \)

If this equation does not hold, an arbitrage opportunity exists.

- \( c \) = value of a European call option to buy one share
- \( X \) = the strike price of the option
- \( p \) = value of a European put option to buy one share
- \( S_0 \) = the current price of the stock
- \( r \) = the risk free rate of interest for maturity \( T \)
- \( T \) = when the option expires

\[
$5 + $48 \cdot e^{(-0.08 \cdot 0.5)} \neq $3 + $50
\]

\[
$51.118 \neq $53
\]

b. (1 point)

- Buy the call
- Buy a zero coupon bond that matures in six months for $48.
- Short the put and the stock

c. (½ point)

(This solution can be determined using more than one formula. An example is shown below.)

\[
(p + S_0 - c - X e^{-rT}) \cdot e^{rT}
\]

\[
\Rightarrow \quad ($53 - $51.118) \cdot 1.041
\]

\[
\Rightarrow \quad $1.882 \cdot 1.041 = $1.959 \text{ per share}
\]
27. (3 points)

a. (1½ points)

Investment strategy:
- buy a call option, C, with a strike X and maturity T
- buy a put option, P, with a strike X and maturity T

Net investment / gain:
There is always an investment required, equal to the cost of the options, C + P.

Profit Scenario(s):
A profit will occur if \( |X - S_T| > (C + P)(1+i) \), where i reflects the interest accumulation factor.

b. (1½ points)

Investment strategy:
- buy a put option, P, with a strike \( X_1 \) and maturity T
- buy a call option, C, with a strike \( X_2 \) and maturity T
\( X_2 > X_1 \)

Net investment / gain:
There is always an investment required, equal to the cost of the options, C + P.

Profit Scenario(s):
A profit will occur if \( (X_1 - S_T) > (C + P)(1+i) \)
or \( (S_T - X_2) > (C + P)(1+i) \)
28. (3 points)

**Strategy A:**

Binomial Trees:

![Call Option: Strike Price $60](image)

- **Equation (9.2)**

\[ f = e^{-rt}[pf_u + (1-p)f_d] \]

- **Equation (9.3)**

\[ p = \frac{e^{rt} - d}{u - d} \]

- **f** = the value of the derivative
- **r** = the risk-free rate
- **t** = the time when the option matures
- **p** = probability of an up movement in binomial nodes, defined in Eq (9.3)
- **f_u** = the value of the option if an up movement occurs
- **f_d** = the value of the option if a down movement occurs

- **d** = one minus the expected down move in the period
- **u** = one plus the expected up move in the period
Question 28 Continued:

**Strategy B:**

Equation (9.8)

\[ f = e^{-2r\Delta t}[pf_{uu} + 2p(1-p)f_{ud} + (1-p)^2f_{dd}] \]

\( \Delta t = \) the length of time associated with each evaluation of the option  
\( f_{uu} = \) the value of the option if two up movements occur  
\( f_{ud} = \) the value of the option if one up and one down movement occur  
\( f_{dd} = \) the value of the option if two downs movement occur

Call Option Value using equation (9.8) = 3.31  
Put Option Value using equation (9.8) = 2.79

Strategy involves selling the call and buying the put:  
\$3.31 - \$2.79 = \$0.52 per share cash gain to the investor
Wiener Process

a = expected drift rate = to be solved for
b^2 = variance rate = 4.0
T = time interval (in qtrs) = 4

Generalized Wiener Process
⇒ dx = adt + bdz

Implied Normal Distribution:

\[ N(x + a\Delta t, \sqrt{b^2 \Delta T}) \]

⇒ \[ N(2.28 + 4a, \sqrt{4 \times 4}) \]

⇒ \[ N(2.28 + 4a, 4) \]

Pr (Cash < 0) = \[ \Phi\left(\frac{0 - 2.28 - 4a}{4}\right)\]

= \[ 1 - \Phi\left(\frac{2.28 + 4a}{4}\right)\]

⇒ \[ \Phi\left(\frac{2.28 + 4a}{4}\right) = 1 - 0.1423 = 0.8577 \]

From Normal Table,

\[ \left[\frac{2.28 + 4a}{4}\right] - 1.07 \]

1.28 + 4a = 4.28

4a = 2

a = drift rate = 0.5
30. (2 points)

Equation (11.2)

\[ \ln S_T \sim \Phi \left[ \ln S_0 + \left( \mu - \frac{\sigma^2}{2} \right) T, \sigma \sqrt{T} \right] \]

\[ S_T = \text{Stock price at time } T \]
\[ S_0 = \text{Stock price at time } 0 = $35 \]
\[ \mu = \text{the expected continuously compounded return} = 18\% \]
\[ \sigma = \text{the stock price volatility} = 24\% \]

\[ \ln S_T \sim \Phi \left[ \ln 35 + \left( 0.18 - \frac{0.24^2}{2} \right) \right. \times 0.5, 0.24 \sqrt{0.5} \]

\[ \ln S_T \sim \Phi [3.555 + 0.1512 \times 0.5, 0.170] \]

\[ \ln S_T \sim \Phi [3.631, 0.170] \]

Substitute \( X \), the strike price for \( S_T \).

\[ P(\ln S_T > \ln X) = 1 - P(\ln S_T < \ln X) = 1 - P \left[ z < \left( \frac{\ln 40 - 3.631}{0.170} \right) \right] \]

\[ 1 - P(z < 0.34) = 1 - 0.6331 \]

Probability of exercise = 0.3669
31. (3 points)

$S_0 = \text{the current stock price (in this case before considering the dividend)}$

$X = \text{the strike price of the option}$

$r = \text{the risk-free rate of interest}$

$T = \text{the time to maturity of the option}$

$\sigma = \text{the stock price volatility}$

$d = \text{the dividend value}$

\[
\begin{align*}
    d_2 &= d_1 - \sigma \sqrt{T} \\
    d_1 - 0.3\sqrt{25} &= d_1 - 0.15 = -0.1086 \\
    d_1 &= 0.0414 \\
    d_1 &= \frac{\ln(S_0/50) + (0.10 + 0.3^2/2) \times 0.25}{0.3\sqrt{0.25}} = 0.0414 \\
    d_1 &= \frac{\ln(S_0/50) + 0.03625}{0.15} = 0.0414 \\
    \Rightarrow \ln(S_0/50) &= (0.0414 \times 0.15) - 0.03625 = -0.03004 \\
    \Rightarrow S_0/50 &= e^{-0.03004} = 0.9704 \\
    \Rightarrow S_0 &= 48.52
\end{align*}
\]

$S_0 = \text{current stock price before considering the dividend}$

PV of the dividend is

\[
    d = 1.50 \times e^{-0.12 \times 0.1} = 1.475
\]

\[
    \Rightarrow S_0 + d = 48.52 + 1.475 = 50.00
\]
32. (3 points)

Sample Formulas:

\[ V = \frac{(V_H + C + V_L + C)}{2(1 + r^*)} \]

\( V \) = the bond’s value based on \( V_H \) and \( V_L \)
\( V_H \) = the bond’s value along the upper path
\( V_L \) = the bond’s value along the lower path
\( C \) = the coupon payment
\( r^* \) = the interest rate at the node in question

\[ r_H = r_L e^{2\sigma} \]

\( r_H \) = the higher one year rate, one year forward
\( r_L \) = the lower one year rate, one year forward
\( \sigma \) = the assumed volatility of the one year rate

\[ r_{HH} = r_{LL} e^{4\sigma} \]
\[ \Rightarrow 5.932\% = 5.055\% \cdot e^{4\sigma} \]
\[ \Rightarrow e^{4\sigma} = \frac{5.932\%}{5.055\%} = 1.174 \]
\[ \Rightarrow 4\sigma = \ln(1.174) = 0.16 \]
\[ \Rightarrow \sigma = 0.04 \]
\[ r_{HL} = 5.055\% \cdot e^{2\sigma} = 5.055\% \cdot 1.083 = 5.476\% \]
\[ r_{LH} = 4.515\% \cdot e^{2\sigma} = 4.515\% \cdot 1.083 = 4.891\% \]
ANSWER FOR QUESTION #32 CONTINUED:

Adjusted for put option.

\[
V_{hh} = \max \left( \frac{(V_{hhh} + V_{hhl} + 2C)}{2(1 + r^*)}, 50 \right) = 50.00
\]

\[
V_{hl} = \max \left( \frac{(V_{hhl} + V_{hlh} + 2C)}{2(1 + r^*)}, 50 \right) = 50.00
\]

\[
V_{ll} = \max \left( \frac{(V_{lhl} + V_{llh} + 2C)}{2(1 + r^*)}, 50 \right) = 50.00
\]

\[
V_h = \left( \frac{(V_{hhh} + V_{hhl} + 2C)}{2(1 + r^*)} \right) \frac{52.50}{1.04891} = 50.05
\]

\[
V_l = \left( \frac{(V_{hhl} + V_{llh} + 2C)}{2(1 + r^*)} \right) \frac{52.50}{1.04515} = 50.23
\]

\[
V = \left( \frac{(V_h + V_l + 2C)}{2(1 + r^*)} \right) \frac{(50.05 + 50.23 + 5.0)}{2(1.04)} = 50.62
\]
Adjusted for put option.
POTENTIAL ANSWERS:

C-1, or Asset Risk:
The insurer may be heavily invested in common stocks. The market value of common stocks may not keep pace with inflation.

Alternative Answer: If the issuer of a bond has a problem coping with inflation (because it cannot pass the extra cost to its customers), the bond can be downgraded and its value goes down.

C-2, or Obligation Risk:
Due to the inflation surge, the actual claims run-off may be significantly larger than the booked loss reserves. Also, inflation could cause expense levels to be higher than expected.

C-3, Interest Rate Risk:
The interest rate surge will have an adverse impact on the market value of the company's fixed income portfolio.

C-4, Mismanagement or Fraudulent Action Risk:
Inflation may dramatically increase the cost of both unpaid claims and claims on future business. An example of mismanagement could be a lack of corrective rate level action to respond to increasing claim costs. An example of fraud would be an intentional, gross understatement of claims reserves to hide financial problems.

(NOTE: There are additional correct responses for each category)
34. (3 points)

a. (1 point)
   
The deterministic factor models the movement from the current interest rate level toward the long-term average interest rate, with the amount of movement set by the speed-of-adjustment factor.

b. (1 point)
   
   1. The expected inflation rate is equal to the simulated interest rate minus X percentage points. (The paper actually uses 2% but the student is not required to remember the value.)
   2. This expected value is assumed to be normally distributed with a given volatility component.
   3. The “actual” inflation rate is then simulated from the normally distributed random variable.

c. (1 point)
   
   1. P&C insurers can re-price products (at least more frequently than life insurers)
   2. P&C insurers are less leveraged than life insurers
   3. P&C fixed income security portfolios generally have a shorter duration, which reduces the volatility of asset values for a given interest rate change

     P&C insurers have a shorter duration of surplus

35. (2 points)

a. (1 point)
   
The model should produce a range of estimates rather than point estimates. Knowing the range of possible outcomes is critical for strategic decision making. In addition to knowing the most likely outcome, it would be important to know the “worst case” scenario for a given strategic option. It would also be important to know the impact on the size of the range for various decision paths.

(Question 35 continued on next page)
b. (1 point)

**DFA Specification Risk:** The inability to adequately understand and specify important functional relationships which leads to changes in asset and liability values.

Is the model structure correct? Are the selected probability distributions correct?

**DFA Process Risk:** The inability to accurately define the joint probability distribution of the model variables (correlation among variables).

Risk of random fluctuations. Actual differs from expected.

**DFA Parameter Risk:** The inability to specify parameters of the distributions in the model.

36. (1 point)

“First, output can be generated using the event files created by different vendors... Comparing the results generated by these different event files, reflecting the different approaches and assumptions of each [modeling] firm, provides a measure of the impact of varying the underlying event parameters, and helps to assure that the results obtained are not dependent on the specific catastrophe model used.”

“Second, sensitivity testing is performed by altering the underlying frequency and severity distributions. Results are routinely tested using higher peril frequencies... The generated peril severity distributions have also been adjusted to consider various factors such as the demand-driven inflation that occurred after hurricane Andrew.”
37. (2 points)

a. (½ point)

One business risk identified by the authors is “regulators or legislators will interfere in the marketplace in an unfair way”. Rate suppression through state regulation is one business risk that has been significant for ABC but would not be significant for XYZ.

b. (½ point)

As an international reinsurer, XYZ faces currency exchange risk, whereas this risk would be nonexistent or minimal for ABC.

c. (½ point)

To evaluate risk, companies are concerned primarily with the likelihood and severity of adverse outcomes. “...Standard deviation focuses only on dispersion of outcomes, without any special recognition of the greater disutility of the adverse outcomes.”

d. (½ point)

- Probability of ruin over the next n years
- Probability of a combined ratio above x%
- The expected policyholder deficit on current business
- Probability of suffering a net decline in surplus of z% or more at the end of n years.
- Probability of failing an RBC test at any point in the next n years
- Probability of a ratings downgrade by A.M. Best
- Probability of a combined ratio z% or more worse than the industry.

- Credit is also given for listing the probability of failing an IRIS test
38. (3 points)

a. (1½ points)

Run 1 measures the impact of liabilities on the firm's total risk. 
Run 2 measures the impact of asset risk on the firm's total risk. 
Run 3 measures the firm's total risk.

b. (1 point)

\[ \text{VAR}(x + y) = \text{VAR}(x) + \text{VAR}(y) + 2 \text{CORREL}(x,y) \times \text{STDEV}(x) \times \text{STDEV}(y) \]
\[ \text{VAR}(L+C+D) = \text{VAR}(L) + \text{VAR}(C+D) + 2 \text{CORREL}(L,C+D) \times \text{STDEV}(L) \times \text{STDEV}(C+D) \]
\[ \text{VAR}(L+C+D) = 20,000 + 4,000 + 2(-0.05) \times \text{SQRT}(20,000) \times \text{SQRT}(4000) \]
\[ \text{VAR}(L+C+D) = 20,000 + 4,000 + 2(-0.05) \times 141.42 \times 63.25 \]
\[ \text{VAR}(L+C+D) = 23,105.52 \]

c. (½ point)

\[ \text{VAR}(\text{Cap. Market} + \text{Disc. Rate}) = 4,000 \]

Portion of total = \( \frac{4,000}{23,105.52} \) = .173 or 17.3%
39. (3 points)

a. (1 point)

Stable P&C insurers generally hold long-term bonds to maturity. The insurers use current premium income and investment income to pay claims.

Stable insurers rarely have to liquidate bonds to pay claims. Feldblum indicates that insolvency is caused by other problems, such as inadequate rates or incompetent management. Duration mismatch only exacerbates the problem for the poorly run insurer; it rarely the causes of the insolvency itself.

b. (2 points)

**Long term bonds:**
Advantages: Higher yields; protection against systematic stock market risks; lowest transaction costs.

Disadvantages: Long durations expose insurer to interest rate risk. Durations longer than liabilities cause duration mismatch. Not a hedge against inflation.

**Common Stock:**
Advantages: Reaction to interest rate changes similar to loss reserves. Higher yield than other assets. Similar to loss reserves, common stock prices are sensitive to inflation (Note: other authors disagree with this last point).

Disadvantages: Increased exposure to systematic stock market risk.

**Commercial Paper or Treasury Bills:**
Advantages: Due to high liquidity, short-term bills have a similar reaction to interest rate changes as loss reserves do. Protection against systematic stock market risk. Inflation hedge.

Disadvantages: Expected yields are too low.

**Real Estate:**
Advantages: Possibly higher returns. Returns are hedge against inflation (NOTE: Other authors may disagree with this).

Disadvantages: Risky, Illiquid and limited by regulation. Require high level of expertise.
40. (2 points)

a. (1 point)

\[ D_{MVS} = \frac{D_{MVA} \cdot MV_A - D_{MVL} \cdot MV_L}{MVS} \]

\[ MVS = (2,500 + 6,500 + 12,000 + 4,200 - 19,800) \]

\[ \Rightarrow 5,400 \]

\[ D_{MVA} = \frac{(2,500 \cdot 1 + 6,500 \cdot 19.23 + 12,000 \cdot 9.46 + 4,200 \cdot 4.28)}{2,500 + 6,500 + 12,000 + 4,200} \]

\[ \Rightarrow 10.28 \]

\[ D_{MVS} = \frac{10.28 \cdot 25,200 - 10.28 \cdot 19,800}{5,400} \]

\[ \Rightarrow 10.28 \]

b. (½ point)

\[ DG_{el} = D_{MVS} - D_{MVA} \]

\[ \Rightarrow 10.28 - 10.28 \]

\[ \Rightarrow 0 \]

(NOTE: Due to rounding, the answer to Part b. may not be exactly zero.)

c. (½ point)

Noris' approximation assumes that dividend rates remain constant in perpetuity. He states: "...the value of a stock is influenced by many other factors in addition to interest rates, indicating that the duration value for stock is, at best, an approximation for its sensitivity to interest rates." Furthermore, Feldblum points out this often produces unrealistically high durations for stocks. As interest rates and inflation change, the dividend value is also likely to change.
41. (2 points)

<table>
<thead>
<tr>
<th>T</th>
<th>CF</th>
<th>PV Factor</th>
<th>PV CF</th>
<th>t * PV CF</th>
<th>(t - D)^2</th>
<th>((t - D)^2)^* PV CF</th>
</tr>
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<tr>
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<td>0.9174</td>
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<td>3</td>
<td>1100</td>
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<td>849.42</td>
<td>2548.26</td>
<td>0.068</td>
<td>57.76</td>
</tr>
</tbody>
</table>

\[ D = \text{Duration} = \frac{2,808.34}{1,025.31} = 2.739 \]

\[ \text{Dispersion} = \frac{381.14}{1,025.31} = 0.372 \]

42. (2 points)

a. (1 point)

- The discount rate should be consistent with the investment yield and inflation assumptions, tax considerations.

- The discount rate should be reflective of a rate of return on equity indicative of the uncertainty associated with realizing the future earnings projections.

b. (1 point)

- When the risk associated with investment income on capital and surplus is directly reflected in the valuation

- When the valuation included the discounted value of future earnings with the discount rate reflecting the buyer’s assessment of risk and the corresponding risk/return requirements. The discount rate should exceed the total internal rate of return required by the buyer.
43. (2 points)

a. (1 point)

Macauley duration assumes a flat yield curve. Barbell or even-ladder strategies violate this assumption and introduce yield-curve risk (non-parallel shifts). Under the bullet strategy there is exact cash flow matching. Therefore, there is no risk.

b. (½ point)

The dedicated bond portfolio, with exact cash flow matching, has minimal market risk, in comparison to duration matching.

c. (½ point)

The duration matched immunization solution is cheaper in price due to the onerous constraint of matching every monthly liability cash flow in a dedicated portfolio strategy.
44. (4 points)

a. (2 points)

\(E[X] = $15,000\)

\[\Rightarrow \text{EPD ratio}_{0.01} = 15,000 \times 0.01 = 150\]

\[
\text{prob}(X = $25,000) \times \int\left(\frac{25,000 - x}{15,000 + A}\right)dx
\]

\[
150 = \frac{\int_{15,000}^{25,000} \left(25,000 - x\right)dx}{10,000}
\]

\[
0.15 \times \left[\frac{25,000x - x^2}{2}\right]_{15,000}^{25,000} - \frac{25,000(15,000 + A)}{2} + \frac{(15,000 + A)^2}{2}
\]

\[
10MM = \frac{312,500,000 - 375,000,000 - 25,000A + 112,500,000 + \frac{A^2}{2} + 15,000A}{2}
\]

\[
40MM - 10,000A + \frac{A^2}{2} = 0
\]

\[A = 10,000 \pm \sqrt{20,000,000}\]

\[A = 5,528 \text{ or } 14,472\]

\$5,528 is the correct answer since $14,472 yields an EPD ratio of 0
Solution to Question #44 Continued:

b. (2 points)

\[ \text{VAR} = E(W) - W^* \]
Where \( E(W) \) = the expected value of the portfolio
\( W^* \) is the lowest portfolio value at the given confidence level
\( \Rightarrow \text{VAR} @ 95\text{th confidence level implies that 95\% of the results are more favorable than } W^* \)

\[ E(W) = E(A) - E(L) = \$20,000 - \$15,000 \]
\[ \Rightarrow E(W) = \$5,000 \]

Since \( W \geq 0 \) when \( L < \$25,000 \), the probability of \( W \leq 0 = 85\% \).
This implies that the worst 15\% of the results occur when \( W \leq 0 \), and the question seeks the value at the 5\% of the worst 15\%.
The 95\text{th percentile} of the joint cumulative probability distribution function, \( F(W) \) is then equal to the 33.3\text{rd percentile} of \( F(A) \) since \( f(A) \) is monotonically increasing, and
\[ F(W) = F(A) - \$25,000. \]

Since \( f(A) \) is uniformly distributed from \( \$15,000 \) to \( \$25,000 \),
\[ f(0.333) = \$15,000 + \$10,000 / 3 = \$18,333. \]
\[ \Rightarrow W^* = \$18,333 - \$25,000 \]
\[ \Rightarrow W^* = -\$6,667 \]
\[ \Rightarrow \text{VAR} = \$5,000 - (-\$6,667) \]
\[ \Rightarrow \text{VAR} = \$11,667 \]