SOCIETY OF ACTUARIES

Quantitative Finance and Investment Portfolio Management Exam

Exam QFIPM

Date: Friday, April 25, 2025

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 13 questions numbered 1 through 13 with a total of 70 points.

   The points for each question are indicated at the beginning of the question.

2. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions provided in this document.

Written-Answer Instructions

1. Each question part or subpart should be answered either in the Word document or the Excel file as directed. Graders will only look at work in the indicated file.

   a) In the Word document, answers should be entered in the box marked ANSWER. The box will expand as lines of text are added. There is no need to use special characters or subscripts (though they may be used). For example, β_1 can be typed as beta_1 (and ^ used to indicate a superscript).

   b) In the Excel document formulas should be entered. Performing calculations on scratch paper or with a calculator and then entering the answer in the cell will not earn full credit. Formatting of cells or rounding is not required for credit.

   c) Individual exams may provide additional directions that apply throughout the exam or to individual items.

2. The answer should be confined to the question as set.

3. Prior to uploading your Word and Excel files, each file should be saved and renamed with your unique candidate number in the filename. To maintain anonymity, please refrain from using your name and use your candidate number instead.

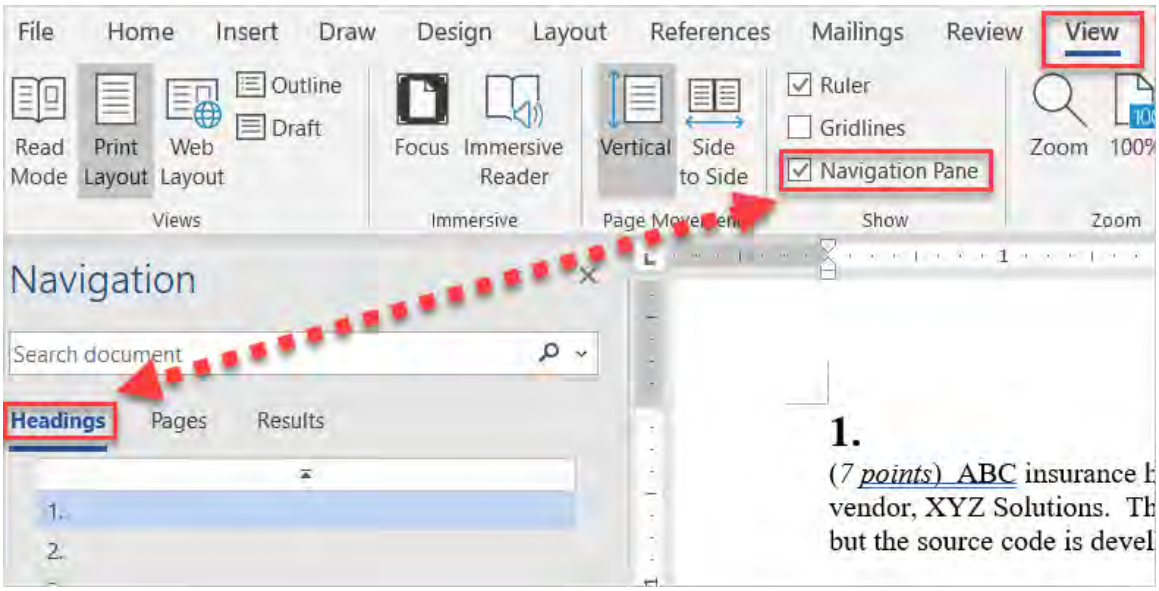
4. The Word and Excel files that contain your answers must be uploaded before time expires.

8770 W. Bryn Mawr, Suite 1000
Chicago, IL 60631

Navigation Instructions

Open the Navigation Pane to jump to questions.

Press Ctrl+F, or click View > Navigation Pane:



1.

(7 *points*) You are working for an investment fund that is expanding its investment portfolio exposure to the hedge fund market.

(a) (*1 point*) List four key elements of hedge funds that distinguish them from mutual funds.

ANSWER:

On January 1, 2023, you implemented a long/short strategy on two non-dividend paying stocks, X and Y, based on the following information:

	Price	Beta	Exposure
Stock X	$45	0.85	Long 150%
Stock Y	$40	1.40	Short 50%
One-year risk-free rate	5%		
Expected market return	8%		
Investment horizon	One year		
Initial investment	$13.5 million		

(b) (*0.75 points*) Calculate the expected return of the long/short strategy according to the CAPM model.

ANSWER:

On December 31, 2023, the price of Stock X increased to $47, and the price of Stock Y decreased to $30.

(c) (*0.75 points*) Calculate the realized return of the long/short strategy.

ANSWER:

(d) (*1 point*) Describe limitations of applying the CAPM model to a long/short strategy involving just two stocks.

ANSWER:

1. Continued

Your associate, Jessie, suggests that convertible bond arbitrage is another appealing investment strategy to consider. She has provided the following information regarding a convertible bond on Stock X:

Values as of January 1, 2023:

- Par value: $1,000
- Coupon rate: 8%
- Market price of bond: $900
- Conversion ratio: 2 0
- Bond delta: 0.5
- Short rebate rate: 5.5%

Values as of December 31, 2023:

- Market price of bond: $964

Jessie claims a one-year convertible bond arbitrage strategy would have earned a higher return than the long/short strategy, had it been implemented on January 1, 2023. Leverage is not allowed for any of the investment strategies. Note the full initial investment is used to buy bonds, and that the proceeds from the short sale should not be considered in determining the initial investment.

(e) (*2.5 points*) Assess the validity of Jessie's claim.

ANSWER:

Your manager prefers to retain some systematic stock market exposure in your fund's portfolio and claims that convertible bond arbitrage should be implemented instead of the long/short strategy.

(f) (*1 point*) Critique your manager's claim.

ANSWER:

2.

(*5 points*) Company X is a hedge fund that has taken a negative view on company Y and is evaluating the purchase of a five-year average life CDS on Y's credit.

Contract	Coupon (bps)	Points Upfront (%)
A	85	4
B	100	3
C	115	2

(a) (*2 points*) Recommend a contract choice.

ANSWER:

(b) (*1 point*) Describe the differences between a CDS contract and an insurance contract.

ANSWER:

(c) (*1 point*) Calculate the upfront put value on the recommended contract if the running spread increases to 500 bps.

ANSWER:

(d) (*1 point*) Recommend a settlement method to include in the contract upon a credit event triggering.

ANSWER:

3.

(*5 points*) You are an investment actuary, developing a factor-based investment portfolio in accordance with "Roger Clarke, Harindra de Silva & Steven Thorley (2016) Fundamentals of Efficient Factor Investing (corrected May 2017)".

Consider a portfolio F, consisting of Market portfolio (M) plus two factors (A and B) satisfying the following conditions:

- Factors A and B are represented by pure factor-replicating portfolios (meaning that subportfolio A has no exposure to factor B and subportfolio B has no exposure to factor A)
- Factors A and B are uncorrelated with each other and are uncorrelated with the market
- Both subportfolios are fully invested with market factor exposures of exactly 1

The parameters for the market factor are: $\mu_M = 6\%$; $\sigma_M = 15\%$
The parameters for factor A are: $\mu_A = 1\%$; $\sigma_A = 5\%$
The parameters for factor B are: $\mu_B = 1\%$; $\sigma_B = 5\%$

(a) (*1 point*) Calculate:

(i) the maximum possible Sharpe ratio for this portfolio

ANSWER:

(ii) the weights for sub portfolio A and B to achieve the maximum Sharpe ratio

ANSWER:

You are given that portfolio F is a long-only portfolio.

(b) (*1 point*) Calculate the Sharpe ratio for the optimal solution of portfolio F.

ANSWER:

3. Continued

The two factors return have non-zero correlation value $\rho_{AB} = 0.20$.

(c) (*0.5 points*) Calculate the maximum possible Sharpe ratio for the portfolio

ANSWER:

(d) (*1 point*) List five factors that would increase the reduction in the expected Sharpe ratio of the portfolio.

ANSWER:

Consider a small cap sub portfolio with expected return of 7.27% and factor risk 16.30%. The sub portfolio contains equally weighted 800 securities each with idiosyncratic risk of 24.04%.

(e) (*1.5 points*) Show that the small cap sub portfolio is a well-diversified portfolio.

ANSWER:

4.

(*5 points*) A company's bond portfolio contains two callable bonds offered by the same bond issuer with A+ rating. The information for the two bonds as of April 1, 2024 is summarized as follows:

	Bond 1	**Bond 2**
Term to maturity	18 months	18 months
Face amount	5 million	5 million
Coupon rate	5%	4.5%
Call schedule	Callable in 9 months, 12 months	Not applicable
Make-whole call premium	Not applicable	50 basis points

(a) (*1 point*) Explain why callable bonds might be preferable to straight bonds from an issuer perspective and from a buyer perspective, respectively.

ANSWER:

(b) (*1 point*) Compare a make-whole callable bond with a fixed-price callable bond.

ANSWER:

You obtained the partial constant-maturity Treasury (CMT) curve from the US treasury website:

	1 Mo	**2 Mo**	**3 Mo**	**4 Mo**	**6 Mo**	**1 Yr**	**2 Yr**	**3 Yr**
04/01/2024	5.49	5.47	5.44	5.41	5.36	5.06	4.72	4.51

(c) (*2 points*) Calculate the market price range at which it is optimal for the bond issuer to call Bond 2 on April 1, 2024.

The response for this part is to be provided in the Excel spreadsheet.

(d) (*1 point*) Describe two other alternative methods a company may use to retire bonds prior to maturity.

ANSWER:

5.

(*7 points*) You are an actuary at ABC Co., a life insurance company whose current investment portfolio is comprised of traditional bonds and stocks. Your CIO has been reviewing hedge fund databases and has observed higher Sharpe ratios than for traditional asset classes.

(a) (*1 point*) Critique the use of the Sharpe ratio to evaluate hedge fund instruments.

ANSWER:

(b) (*2 points*) Explain how three potential biases arise in the performance metrics reported in hedge fund databases.

ANSWER:

Your CIO is interested in investing in SVS Co., a new hedge fund.

On June 30, 2023:

- An initial investment of $1 million was made into SVS Co.
- SVS also sold 20% OTM strangles on the S&P500 index with 6-month maturities.
- Each 20% OTM strangle on the S&P500 index with a 6-month maturity was selling for $57.50.
- SVS applied both its initial investment and the proceeds from the strangles into U.S. 6-month T-bills.
- U.S. 6-month T-bill rates were yielding 6%, compounded annually.
- The S&P500 index level was 5,000.

On December 31, 2023:

- SVS Co's Sharpe ratio was 7.14 and its standard deviation was 0.42% over the last 6 months.
- S&P 500 index level is 5,000 as markets have been stable over the 6-month period ending December 31, 2023.

5. Continued

(c) (*3 points*) Calculate the S&P500 index level on December 31, 2023 that would have reduced SVS Co.'s Sharpe ratio to 0.

The response for this part is to be provided in the Excel spreadsheet.

Your colleague performs a portfolio mean-variance optimization algorithm to determine an appropriate allocation to SVS Co. within your company's portfolio.

(d) (*1 point*) Critique your colleague's approach.

ANSWER:

6.

(*5 points*)

(a) (*1 point*) Explain how an investment manager can outperform their benchmark.

ANSWER:

Company ABC has the following portfolio performance over a year.

Asset Category	**Policy Allocations**	**Actual Return**
Domestic Equities	75%	6.20%
Domestic Fixed Income	25%	2.80%

	Policy Allocations	**Actual Return**	**Benchmark Return**
Domestic Equities			
Manager A	20%	7.00%	7.00%
Manager B	80%	6.00%	8.00%
Domestic Fixed Income			
Manager C	40%	1.00%	2.00%
Manager D	60%	4.00%	3.00%

The risk-free rate is 1%.

Returns from two market indices are as follows:

Equities	7.50%
Fixed Income	2.50%

(b) (*1 point*) Analyze the performance of the four managers by considering returns due to style and active management.

ANSWER:

6. Continued

One of the managers contends that the benchmark used to evaluate his portfolio does not properly represent his investment style.

(c) (*1 point*) Describe two ways to test the quality of the benchmark.

ANSWER:

Assume no cash flows occurred during the year.

(d) (*1 point*) Evaluate the performance of Company ABC's overall portfolio using macro attribution return metrics in the following levels:

(i) Asset Category

ANSWER:

(ii) Investment Managers

ANSWER:

(e) (*1 point*) Describe four levels for investment policy decision making in addition to Asset Category and Investment Managers.

ANSWER:

7.

(*6 points*) You are given the following information about a newly established CLO (Collateralized Loan Obligation) company.

- The company's assets consist of five groups of loans (Group 1 through Group 5), all purchased at par value
- The company's liabilities consist of three classes /tranches of debt (Class A, B and C), all issued at par value
- The maturity of each group of loans and each class of debt exceeds 10 years
- The company's equity owner contributed $70 million and is entitled to any residual cash flows after all liability payments are satisfied
- No asset reinvestment is to be made
- All asset and liability cash flows (coupon payments) are assumed to occur at the end of the year
- All fees and transaction costs (such as trustee fee, asset manager fees...) are assumed to be $0
- The minimum values to pass the par coverage test are shown below

Class A	Class B	Class C
1.25	1.10	1.05

- Defaulted assets are to be excluded from the par coverage tests
- The recovery rate for any defaulted assets is 0%

The company's asset and liability data are shown below (millions)

Assets (Loans)	Coupon Rate	Par Amount
Group 1	5.25%	100
Group 2	5.70%	110
Group 3	6.30%	150
Group 4	7.00%	160
Group 5	7.30%	200
Total		720

Liability	Coupon Rate	Par Amount
Class A (most senior)	5.50%	250
Class B (middle class)	6.00%	300
Class C (most junior)	7.00%	100
Total		650

	Capital Amount
Class E (Equity)	70

7. Continued

You are also provided the following asset default rate assumptions:

Annual Default Rates

Assets (Loans)	Year 1 Default Rate	Year 2 Default Rate	Year 3 Default Rate	Year 4 Default Rate
Group 1	0.0%	3.0%	8.0%	10.0%
Group 2	1.0%	4.0%	9.0%	12.0%
Group 3	1.5%	5.0%	10.0%	15.0%
Group 4	2.0%	7.0%	15.0%	20.0%
Group 5	2.5%	8.0%	20.0%	30.0%

(a) (*2 points*) Calculate the total cash flows to Class A, B, C, and E, respectively, at the end of the first year.

The response for this part is to be provided in the Excel spreadsheet.

(b) (*1.5 points*) Calculate the principal payment to Class A at the end of the second year.

The response for this part is to be provided in the Excel spreadsheet.

(c) (*1.5 points*) Calculate the interest payment to Class B at the end of the fourth year.

The response for this part is to be provided in the Excel spreadsheet.

(d) (*1 point*) Explain what is meant by "the CLO is bankrupt remote."

ANSWER:

8.

(*6 points*) ORD is a mid-sized Life insurance company that sells term and whole life insurance as well as fixed indexed annuities. ORD is looking to expand its annuity business over the next 5 years. You head up the ALM department at ORD and you are explaining risk objectives and how they affect life insurance companies to the ORD board.

(a) (*1 point*) Describe

(i) Valuation concerns

ANSWER:

(ii) Reinvestment risk

ANSWER:

Besides interest rate risks, you will need to address other risks to manage risk objectives that help to address asset-liability duration mismatch.

(b) (*1 point*) Describe two other risks and how they impact ORD's risk objectives.

ANSWER:

ORD has set one of its return objectives to be a net interest spread of 1%.

(c) (*1.5 points*)

(i) Define net interest spread.

ANSWER:

(ii) Describe the consequences to ORD of not meeting the return objective.

ANSWER:

(iii) State the strategies that ORD could use to meet the return objective.

ANSWER:

8. Continued

ORD is assessing its liquidity needs.

(d) (*1 point*) Describe two risks that ORD must address.

ANSWER:

(e) (*1.5 points*) Describe three common regulatory and legal considerations that may impact ORD.

ANSWER:

9.

(*4 points*) STL is a comprehensive financial services firm dealing in a broad variety of insurance and loan products. You have recently joined this firm to provide expertise with respect to matching insurer funds against their liabilities.

STL management has expressed interest in developing an immunizing portfolio for a collection of its liabilities. You are involved in a meeting preparing to implement the appropriate strategies, where the following statements are made by the STL team:

- Liquidity is a key consideration for securities in an immunized portfolio.
- Immunization achieves the objective of ensuring that the surplus will remain unchanged for small changes in interest rates.

(a) (*1 point*) Explain whether each of the above statements is true or false.

ANSWER:

The company elects to move forward with a plan to immunize a selection of its liabilities. Later, the company requests your support in evaluating the immunizing portfolio.

Portfolio Information (at t=0)

Asset	Market Value	Duration
Bond A	1,086,962	6.185
Bond B	984,157	2.343
Bond C	1,032,565	5.674

Portfolio Information prior to rebalancing (at t =1)

Asset	Market Value	Duration
Bond A	1,042,390	5.298
Bond B	1,011,682	1.406
Bond C	1,002,693	4.817

(b) (*2 points*) Calculate the new market value of each bond required to reestablish the dollar duration of the portfolio.

The response for this part is to be provided in the Excel spreadsheet.

9. Continued

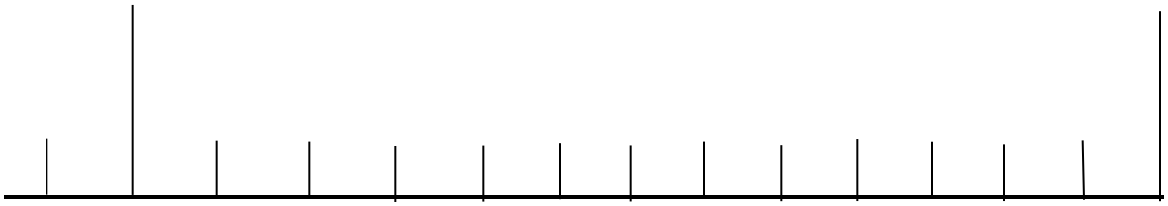
Continuing your analysis of the company's immunized portfolio positions, you are asked to examine the cash flow patterns for two separate portfolios. The timelines for each portfolio are provided below. A vertical line represents a cash flow, and the size of the line indicates its magnitude. Each diagram supports a liability at a known time equal to the Horizon Date.

Portfolio A

T = 0 T = H

(Current Date) (Horizon Date)

Portfolio B



T = 0 T = H

(Current Date) (Horizon Date)

(c) (*1 point*)

(i) (*0.25 points*) Identify which of the portfolios best represents a barbell portfolio and which best represents a bullet portfolio.

ANSWER:

(ii) (*0.75 points*) Justify which portfolio has greater risk exposure for non-parallel rate shifts.

ANSWER:

10.

(*5 points*)

(a) (*1.5 points*)

(i) (*0.5 points*) Describe the concept of market value as it relates to real estate.

ANSWER:

(ii) (*0.5 points*) Describe the concept of investment value as it relates to real estate.

ANSWER:

(iii) (*0.5 points*) Describe two reasons why market value may differ from investment value for a real estate investor.

ANSWER:

In this market, all loans are perpetual and the prevailing interest rate on mortgages is 5%. In addition, there is a market for tax-exempt debt, where the prevailing market interest rate is 3.5%.

There are three investors interested in the same property.

- Investor A is a marginal investor.
- Investor B has the same expected pre-tax cash flows as Investor A with a lower marginal income tax rate of 20%.
- Investor C is a chain store owner. She estimates that she can generate $60,000 total annual cash flows with this property due to synergy from her other stores. Her marginal tax rate on investment is 35%.

All three investors would plan to borrow $1 million to help finance this real estate investment.

10. Continued

(b) (*3.5 points*)

(i) (*0.5 points*) Calculate the effective tax rate on mortgage interest income faced by marginal investors in the debt market.

The response for this part is to be provided in the Excel spreadsheet.

(ii) (*1 point*) Calculate the investment value for investor A.

The response for this part is to be provided in the Excel spreadsheet.

Investor C is a savvy investor and can negotiate a better market interest rate than what is currently offered.

(iii) (*2 points*) Calculate the pre-tax market interest rate that would produce the same investment value for investors B and C.

The response for this part is to be provided in the Excel spreadsheet.

11.

(*5 points*) A company holds a portfolio consisting of Zero-Coupon Bond (ZCB) assets summarized in the table below:

Asset	MV ($ millions)	Yield	Modified Duration	Rating	Liquidity
3-year ZCB	100	6%	3	BB	Low
5-year ZCB	300	4%	5	AA	High
10-year ZCB	100	5%	10	BBB	Medium

The assets are used to support $500 million in reserves supporting a 7-year Fixed Annuity product. The Fixed Annuity has a liability modified duration of 6.

(a) (*1 point*) Calculate an estimate of the profit/loss given a 100bps parallel decrease in interest rates.

ANSWER:

An analyst in the investments team suggests that by reallocating assets, a higher yield can be achieved on the portfolio. The only risk tolerance the company has in place on the portfolio is a maximum duration mismatch of 0.5.

(b) (*1.5 points*) Construct the portfolio allocation that gives the maximum yield on the assets while remaining within the company's risk tolerance.

ANSWER:

The analyst makes a recommendation that the company should reallocate to the portfolio in part b), since it offers a higher yield while still remaining within the company's risk guidelines.

(c) (*1.5 points*) Critique the analyst's recommendation.

ANSWER:

11. Continued

A Board member has cautioned against explicitly benchmarking the asset portfolio performance against a common fixed-income index because of adverse selection bias.

(d) (*1 point*) Explain adverse selection bias in the context of benchmarking to a common fixed income index.

ANSWER:

12.

(*5 points*) Your consulting firm was hired by WOW Endowments to recommend improvements to their investment strategy, with a particular focus on strategic asset allocation.

WOW Endowments, whose current assets total $525 million, has shared the following cash flows (in $millions) from recent years:

	2022	**2021**	**2020**	**2019**	**2018**
Net Investment Income	10.0	25.5	22.2	21.0	19.8
Gifts Spending	(7.1)	(8.4)	(9.1)	(8.0)	(7.5)
Donations Received	0.5	0.2	0.0	0.2	0.2
Administrative Expenses	(0.5)	(0.5)	(0.7)	(0.4)	(0.4)
Investment Expenses	(2.7)	(2.6)	(3.5)	(2.3)	(2.3)
Net Income	**0.2**	**14.2**	**8.9**	**10.5**	**9.8**

You have noted the following key points from WOW's current IPS:

- WOW has been a key supporter of various communities and aims to maintain that promise
- Investments will emphasize principal protection through income generation that meet annual gift giving, anticipated inflation, and expense needs
- An annual gross return of 7.0% is expected to meet the above cash flow needs
- Emphasis will be on short-to-medium term investments to limit shortfall risk within the next 1-3 years
- Liquidity needs will be met by allocating at least 20% of the portfolio in cash or cash equivalents

Risk constraints are as follows:

- Sharpe Ratio is to be above 47.5%
- Equities (domestic and international combined) will have a maximum allocation of 20%
- Allocation to other individual asset classes will not exceed 50%

12. Continued

WOW also aims to maximize its utility function given as:

$$U_m = E(R_m) - 0.5R_A\sigma_m^2$$

The current risk aversion parameter is 4.0 and will be revisited every 3 years.

(a) (*1.5 points*) Recommend two improvements to the IPS.

ANSWER:

Reviewing the historical data of the permissible asset classes (over 10 years) included in the IPS:

Asset Class	Mean Return	Standard Deviation	Min Return	Max Return
Cash Equivalents	2.0%	0.4%	1.3%	3.0%
U.S. Medium-Term Bonds	5.0%	1.5%	-1.0%	7.0%
U.S. Long-Term Bonds	7.0%	2.0%	1.0%	9.5%
U.S. Equities	14.5%	20.0%	-10.2%	42.8%
International Equities	15.5%	35.0%	-15.0%	37.0%

The current portfolio allocation yields an expected return of 7.5%, with a standard deviation of 10.0%, and a utility of 0.055.

Your colleague has been researching additional asset classes to bolster portfolio performance. They have created 3 corner portfolios under a Mean-Variance Optimization, where each corner portfolio is a combination of the current portfolio selected and only one new asset class.

Additional Asset	New Portfolio Expected Return	New Portfolio Standard Deviation	Correlation with Current Portfolio
A	6.0%	6.67%	0.88
B	9.3%	12.0%	0.75
C	8.5%	11.0%	0.65

12. Continued

If Asset A is added to the portfolio, the Sharpe Ratio is unchanged.

(b) (*1.5 points*) Identify the optimal Asset among A through C to add to the portfolio if the key metric is:

(i) Maximizing Sharpe Ratio

The response for this part is to be provided in the Excel spreadsheet.

(ii) Maximizing Utility Function

The response for this part is to be provided in the Excel spreadsheet.

As an alternative to the proposed portfolio, you are considering suggesting the Board consider an optimal portfolio on the capital allocation line, based on the three corner portfolios.

(c) (*2 points*)

(i) (*0.5 points*) Define the capital allocation line.

The response for this part is to be provided in the Excel spreadsheet.

(ii) (*1.5 points*) Calculate the maximum risk aversion parameter for which the optimal corner portfolio would lie on the capital allocation line.

The response for this part is to be provided in the Excel spreadsheet.

13.

(*5 points*) Insurance company ABC periodically needs to raise cash to address short-term liquidity needs. To address the company's short-term liquidity needs, the CFO has suggested entering either a repurchase agreement ("repo") or a 5-year revolver. It has entered discussions with Bank XYZ as a counterparty.

The proposed repo would have the following characteristics:

- The repo would last for 10 days
- The repo would involve a highly rated corporate bond from ABC's surplus portfolio with a market value of $100M and a 3% haircut.
- The repo rate is 0.12%.

(a) (*1 point*) Describe the exchanges involved in the above repo transaction, including the timing of each exchange and the amounts exchanged. Round amounts to the nearest thousand dollars after the last calculation.

ANSWER:

Bank XYZ is looking to minimize its overall level of credit risk and is analyzing the exposure involved in either a repo or revolver.

- The revolver would have a notional amount of $150M.
- For purposes of net exposure calculations, XYZ assumes a 20% valuation haircut for the repo collateral.
- Clients of XYZ have historically utilized 10% of their revolvers, so XYZ assumes an expected Usage Given Default (UGD) of 10%.

(b) (*1 point*) Critique XYZ's expected UGD of 10%.

ANSWER:

(c) (*1 point*) Calculate the Gross Exposure, Net Exposure, and Adjusted Exposure for each transaction (the repo and the revolver).

ANSWER:

13. Continued

(d) (*1 point*) Identify three additional dimensions of a transaction other than Exposure that can be used to analyze and compare credit exposures.

ANSWER:

(e) (*1 point*) Recommend whether Bank XYZ should enter into either the repo or the revolver.

ANSWER:

END OF EXAMINATION*