SOCIETY OF ACTUARIES

Quantitative Finance and Investment Portfolio Management Exam

Exam QFIPM

Date: Friday, April 26, 2024

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 14 questions numbered 1 through 14 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 five-digit candidate number in the filename.

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

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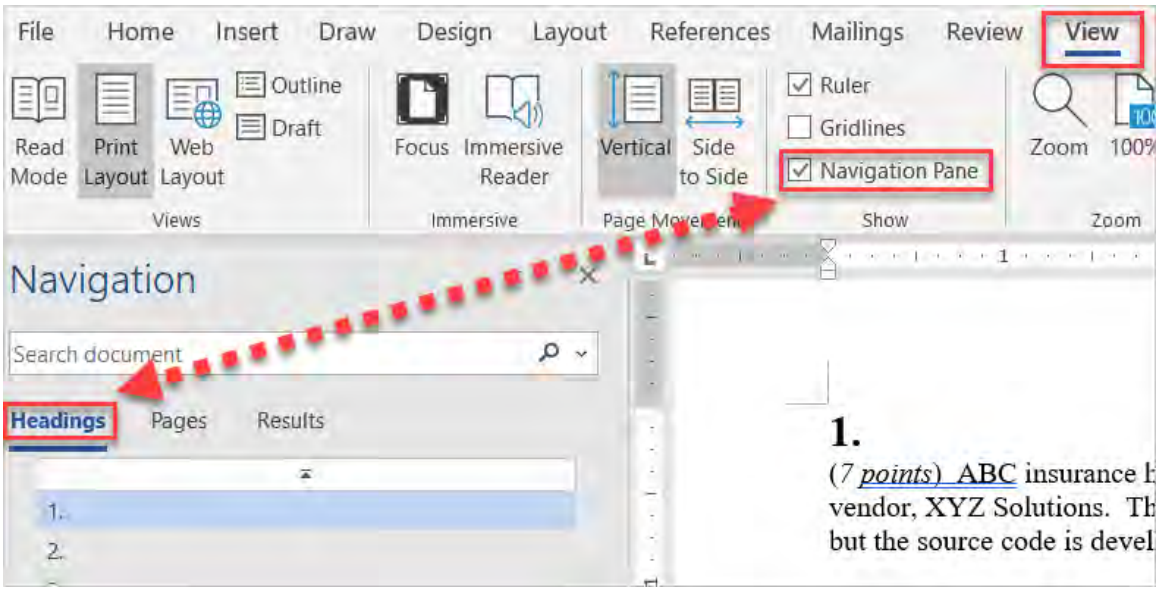
Navigation Instructions

Open the Navigation Pane to jump to questions.

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



1.

(*5 points*) You are an investment actuary at YKF Insurance company. Your company has some existing investments in alternative assets and is considering increasing its investments in crude oil.

An actuarial associate suggests that the best way for YKF to increase its exposure to crude oil is by investing in the stocks of oil companies.

(a) (*1 point*) Explain the limitations of this strategy.

ANSWER:

Instead, you are considering commodity-linked notes as potential investments.

(b) (*0.5 points*) Describe the advantages commodity-linked notes have over investing directly in oil or oil futures.

ANSWER:

Consider the following two notes purchased today, both are at par with a principal of $2,000,000 and have a maturity of one year with an annual coupon paid at maturity:

- The principals of both bonds are tied to the crude oil price, currently $70
- Note 1 is principal protected with the strike price of the embedded call option being $77. Its coupon rate is 3%
- Note 2 is not principal protected. Its coupon rate is 6%

(c) (*1.5 points*) Calculate the payout of each of these two notes at maturity if the crude oil price is $85 at that time.

ANSWER:

1. Continued

Another associate suggests that commodity futures is another appealing asset class to consider. She has provided the following information regarding an oil futures contract:

- Maturity time: 6 months
- Price of the contract: $75
- Spot price: $70
- Expected annual growth of oil price: 10%
- Storage cost of oil: 2%, continuously compounded
- Risk-free interest rate: 5%, continuously compounded

(d) (*2 points*) Construct an arbitrage strategy with this contract.

ANSWER:

2.

(*4 points*) You are an investment analyst working at ABC Equities and are developing investment indices and passive investment vehicles.

You are given the following information on the four stocks that comprise the QXYZ index:

Stock	**Share Price, Dec. 31 2024**	**Share Price, Dec. 31 2025**	**Market Value ($M) of Shares, Dec. 31 2024**	**Market Value ($M) of Shares, Dec. 31 2025**
Q Corp	32.88	22.17	$11,349	$7,652
X Corp	19.54	28.96	$22,762	$33,735
Y Corp	23.84	44.79	$98,455	$184,975
Z Corp	58.47	50.23	$120,873	$103,839

(a) (*1 point*) Calculate the returns of the QXYZ index using:

(i) Value-weighted method

(ii) Equal-weighted method

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

(b) (*0.5 points*) Describe a key bias in the performance measurement for each of the two index weighting methods.

ANSWER:

An investment manager at your firm has a mandate for managing a G3000 index fund, which contains over 3,000 small-cap stocks. You're asked to consider the use of the full replication method and the stratified sampling method.

(c) (*1 point*) Explain why the return on an index fund constructed using the full replication method may be less than the return of the underlying index.

ANSWER:

(d) (*0.5 points*) Describe the stratified sampling method.

ANSWER:

2. Continued

(e) (*1 point*) Recommend the most appropriate method for constructing the G3000 index fund.

ANSWER:

3.

(*4 points*) You manage a team of actuarial students, who are analyzing risks and returns of hedge funds.

Your students made the following comments about the risks faced by hedge funds.

1. Process risk is a type of fundamental risk due to the general lack of transparency associated with it.
2. Beta expansion risk occurs when hedge fund managers short the same securities.
3. Off-balance sheet risk can be due to short volatility risk, fund manager skill risk, and mapping risk.

(a) (*2 points*) Critique each statement.

ANSWER:

Based on research work on public companies A and B, your student team proposed a stub trading strategy on companies A and B. Company's A ownership in Company B contributes to 25% of Company's A's consolidated operating income. The relevant information is given below:

	On the date the trading strategy began	On the date the trading strategy ended
Company A's share price	$50	$56
Company B's share price	$40	$44
Based on the student team's research work, the share price of Company A's own operation (i.e., when excluding A's ownership in B)	$42	$45
Neither A nor B pays dividends; Transaction cost = $0; A and B have issued the exact same number of shares.		

(b) (*2 points*) Construct this strategy.

ANSWER:

4.

(5 *points*) You are working for ABC Investment Company, a firm that has historically been a prominent market participant in Leveraged Buyouts (LBO) and providing financing for venture capital deals. ABC Investment Company's senior management team is considering exiting the venture capital market due to concerns it is riskier than LBOs.

(a) (*1 point*) Explain why LBOs are generally less risky than providing financing for venture capital deals.

ANSWER:

Two publicly traded companies, GHI and LMN, stated that they are openly pursuing offers for the sale of their companies. You are given the following information:

Information / Metric	**GHI**	**LMN**
Years in Business	1	75
Industry	Electric Vehicle Maker	Grocery
1 Year Change in Stock Price	+15%	-50%
Price-to-Book Value Ratio	5.0	0.5
Net Margin	-1%	8%
1 Year Percent Change in Number of Employees	+5%	+20%
Debt-to-Equity Ratio	2.0	0.2

(b) (*2 points*) Assess whether ABC should pursue a LBO for each company.

ANSWER:

4. Continued

ABC just closed on the LBO of another company, TUV, for a purchase price of $500 million, of which $300 million is financed with five-year debt. ABC plans to sell TUV immediately after paying off the debt in five years and targets a 30% annual compound return on its initial equity investment over the five-year investment period.

(c) (*1 point*) Calculate the minimum amount from a sale of TUV that ABC needs to receive at the end of the investment period in order to meet its annual compound return target.

ANSWER:

(d) (*1 point*) Describe the risks with this transaction that may cause ABC not to achieve the annual compound return target.

ANSWER:

5.

(*4 points*) You have been hired as a real estate subject-matter expert for a large financial institution that is exploring different investments to add to their general account portfolio.

(a) (*1 point*) Compare and contrast residential mortgages and commercial mortgages on the basis of:

(i) volume in the market

(ii) loan size

(iii) income generation of the underlying property

(iv) characteristics of the borrower

ANSWER:

As part of your new role, you have been asked to work on a project assessing a Commercial Mortgage-Backed Security (CMBS).

The CMBS structure is as follows:

- There are 100 loans backing the CMBS
- Each loan has an outstanding loan balance of $0.5 million and a coupon (contract) interest rate of 10%
- Tranche A is a Senior (Investment-Grade) class which occupies 75% of the total par value of the underlying loan pool paying an 8% annual coupon
- Tranche B is a Junior (Non-Investment-Grade) class occupying the remaining 25% of the underlying loan pool's par value paying a 16% annual coupon
- Half of the loans mature at the end of 5 years, with the other half maturing at the end of 10 years
- The loans are all non-recourse, with lockouts preventing prepayments

Your co-worker makes the statement, "Tranche B is very attractive given that the risk is not all that different from Tranche A".

(b) (*1 point*) Critique the statement.

ANSWER:

5. Continued

Now suppose that the lockout provision has been eliminated from each of the underlying loans, meaning that each borrower is permitted to make a prepayment. You are told that the following prepayments have just occurred today:

- 25 of the loans maturing at the end of 10 years have repaid the entirety of their outstanding loan balance
- 25 of the loans maturing at the end of 5 years have repaid half of their outstanding loan balance

(c) (*1 point*) Calculate the amount outstanding in Tranche A and Tranche B after the prepayments.

ANSWER:

Your company's Chief Financial Officer (CFO) is considering investing in Tranche B due to its attractive potential returns. However, you are worried about the underlying credit risk of such an investment.

(d) (*1 points*) Recommend a strategy that balances your CFO's desire to increase shareholder returns with your concern of downside risk.

ANSWER:

6.

(*5 points*) ATW insurance company has several asset classes supporting its individual life portfolio. ATW uses a strategic asset allocation (SAA) and the assets, which are all domestic, are rebalanced at the end of every year

Asset Class	Target Allocation	Long-Term Expected Return
Cash Equivalent	5%	0.5%
Investment Grade Public Bonds	40%	4.0%
Private Placement Bond	20%	6.0%
Public Common Stock	20%	8.5%
Commercial Mortgage Loan	10%	6.5%
Real Estate	5%	6.0%

ATW is considering a tactical asset allocation (TAA) for the individual life portfolio to enhance investment return. TAA is frequently based on the following 3 principles:

1) Market prices tell explicitly what returns are available.
2) Relative expected returns reflect relative risk perceptions.
3) Market is rational and mean reverting.

You are given the following facts:

- Public Common Stock: volatility ratio has been exceeding the equity risk premium for 2 years
- Investment Grade Public Bonds: total return has been 1% over the past 5 years

(a) (*1 point*)

(i) Explain principle 1) above

ANSWER:

(ii) Explain how principle 1) can help derive the long-term return expectations for Public Common Stocks.

ANSWER:

6. Continued

(b) (*1 point*) Describe how principles 2) and 3) above may affect the tactical allocation of the Public Common Stocks and Investment Grade Public Bonds respectively.

ANSWER:

Within the Public Common Stocks asset class, you are asked to consider combining a current market portfolio with factor-replicating portfolios A and B, which replicate factors F_A and F_B respectively. Portfolio A has no exposure to factor F_B and Portfolio B has no exposure to factor F_A. You have the following views on expected portfolio returns:

Portfolio	Return in excess of the risk-free rate	Active Return in excess of the market return	Volatility	Active Risk
A		0.00%		4.00%
B		1.00%		2.50%
Market	6.00%		15%	

Returns for portfolio A and B have a correlation of -0.2 and are assumed to be uncorrelated to the market.

Using the generalized Treynor–Black result from the paper "Fundamental of Efficient Factor Investing" by Roger Clarke, Harindra de Silva & Steven Thorley:

(c) (*3 points*)

(i) (*1 point*) Calculate the Maximum possible factor Sharpe ratio for a portfolio composed of the above factors and the market portfolio.

ANSWER:

(ii) (*2 points*) Calculate the excess return over the risk-free rate of the maximum possible factor Sharpe Ratio portfolio.

ANSWER:

7.

(*6 points*) You have been asked to review the funds available for your company's Variable Universal Life product.

There are currently three funds which are invested in individual securities to replicate a particular investment style.

The benchmarks currently in use to assess performance are as follows:

Fund	Investment Style	# of stocks used	Number of independent trades per year	Information Coeffficient
Fund A	Mid Cap Value	D	X	.03
Fund B	Large Cap Growth	E	Y	.02
Fund C	Small Cap Core	400	100	.05

The Information Coefficient is defined as the correlation between the forecasted return and the actual return.

You are given the following information about Fund B

Portfolio Statistics	Fund B	Market Benchmark
Number of stocks	100	750
Weighted Average Market Cap	$37b	$45b
Dividend yield	1.5%	2.1%
P/E	25	20
EPS Growth (5 year projected)	10%	12%
Earnings Variability of stocks	0.5	1.0
Sector Weights		
Consumer Discretionary	13%	13%
Consumer Staples	10%	10%
Energy	9%	9%
Finance	15%	20%
Health Care	4%	7%
Industrials	9%	9%
Information Technology	12%	7%
Materials	8%	8%
Telecommunications	10%	10%
Utilities	10%	7%

7. Continued

(a) (*2 points*) Assess whether the stock selection above is consistent with a Growth Style.

ANSWER:

The funds do not allow short selling stocks.

(b) (*1 point*) Explain two reasons why short selling stocks may be a strategy to consider.

ANSWER:

The expectation of each fund is to have a similar Information Ratio under Grinold and Kahn's Fundamental Law of Active Management.

(c) (*1 point*)

(i) Calculate the number of annual independent trades per year necessary for Fund A to have the same Information Ratio as Fund C.

ANSWER:

(ii) Explain why Portfolio B should require a higher number of annual trades in order to achieve the same Information Ratio.

ANSWER:

7. Continued

You are looking at the current fee structure of the funds. Below is relevant information to consider:

Fund	Invested Funds	Fee for first 200M	Fee above 200M	Expected Alpha
Fund A	500M	50bp	40bp	0.02
Fund B	1000M	100bp	50bp	0.04
Fund C	100M	20bp	10bp	0.0

You are considering a performance based fee for Fund A where you would pay Zbp + 10% in excess of the benchmark return.

(d) (*1 point*) Calculate Z so that the total fees under either approach are equal.

ANSWER:

(e) (*1 point*) Explain two additional features that could be added to the performance-based fee formula to better align the fund managers incentives with the your company's interests.

ANSWER:

8.

(*6 points*) You provide portfolio management services to clients, working with a variety of assets.

One of your clients has frequent deposits and withdrawals to their account. They are anxious about the portfolio's performance and request periodic updates on the portfolio return.

(a) (*1 point*)

(i) Compare the time-weighted rate of return and the money-weighted rate of return.

ANSWER:

(ii) Explain which measure you would use when reporting to your client.

ANSWER:

(b) (*1 point*) Explain what an investment policy is and why it is important to portfolio design.

ANSWER:

You are given the following information for one of your managed stock portfolios:

	Investment Policy		Portfolio	
	Policy (Passive) Weight	Passive Return	Actual Weight	Active Return
Asset Class 1	60%	10%	50%	11%
Asset Class 2	40%	9%	50%	10%

(c) (*2 points*) Calculate the portfolio's return, attributed to each of the following dimensions:

(i) Investment policy

ANSWER:

8. Continued

(ii) Timing

ANSWER:

(iii) Selection

ANSWER:

(iv) Other

ANSWER:

(d) (*1 point*) Describe the considerations of performance micro-attribution for fixed income portfolios.

ANSWER:

(e) (*1 point*) Identify potential drawbacks to using past performance data to evaluate portfolio managers.

ANSWER:

9.

(*4 points*) Bank XYZ has experienced significant growth in recent years with its balance sheet tripling in size over the last three years. Management is looking into a method to reduce its balance sheet as well as required regulatory capital.

You are asked to look into selling a portion of the bank's loan portfolio to Collateralized Loan Obligations (CLOs).

(a) (*1.5 point*) Explain the four important attributes of CLOs.

ANSWER:

(b) (*1.5 point*) Describe a cash flow waterfall with par coverage test.

ANSWER:

Assume the asset of a CLO has a promised yield of 10%, and 90% of the CLO portfolio is funded with CLO debt costing an average of 5%. CLO equity receives no cash unless CLO debt is repaid in full.

(c) (*1 point*) Describe the scenarios where CLO equity experiences the maximum and minimum returns.

ANSWER:

10.

(*7 points*) You are an actuary at ABC Pension Company, an actuarial consulting company specializing in pension funding and risk management. A client of yours, XYZ Company, currently has pension plan investments with the following characteristics:

	Assets		Liabilities
	Bonds	Equity	
Value	$475 million	$200 million	$500 million
Duration	12	-	10
Volatility	0.15	0.20	

The plan requires that surplus risk is minimized with an equity allocation of no less than 5.0%. Assets are invested in bonds and equity. The plan is considering moving the domestic bond allocation into an index with the following characteristics:

	Bond Index X
Volatility	0.12
Correlation with Equities	0.18

You choose to model the liabilities using the model form described in the Litterman reading:

$$R_{L,t} - R_{f,t} = \beta(R_{B,t} - R_{f,t}) + \varepsilon_t$$

where $R_{L,t}$ = Total return on the liability index at time t
$R_{f,t}$ = Risk-free rate of return
$R_{B,t}$ = Total return on a bond index
ε_t = Noise term

and where beta represents the ratio of the liability duration to the bond index duration.

(a) (*2 points*) Calculate the minimum duration of Bond Index X such that the pension plan's surplus risk requirement is satisfied.

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

10. Continued

The investment goal of the pension plan is to maximize the risk-adjusted change in surplus (RACS). Your client suggests the equity allocation should be doubled in order to achieve this goal.

(b) (*1 point*) Critique your client's statement.

ANSWER:

The asset allocation for the plan has now been adjusted to have the following characteristics:

	Domestic Bonds	**Domestic Equity**	**Global Equity**
Allocation	$475M	$150M	$50M
Sharpe Ratio	0.10	0.16	0.17
Volatility	0.12	0.22	0.27
Correlation with Liabilities	0.75	0.2	0.05

You have learned that the future pension liability value is now more uncertain due to potential legislative changes.

(c) (*1 point*) Explain the relative impact this uncertainty will have on the optimal asset allocations for

(i) domestic bonds

(ii) domestic equity

(iii) global equity

ANSWER:

Your client wishes to maintain equity return levels with a lower direct investment in equities.

(d) (*1 point*) Design an investment strategy that will accomplish this.

ANSWER:

10. Continued

Your client is now considering implementing this strategy. They wish to understand the different implementation approaches that could be used.

(e) (*2 points*) Describe three potential implementation approaches for your strategy, including the benefits and drawbacks of each.

ANSWER:

11.

(*4 points*)

(a) (*1 point*) Explain how credit default swaps (CDS) provide protections to the buyer and why CDS is not an insurance product.

ANSWER:

You are given a loan portfolio with the following characteristics:

- The portfolio consists of 1,000 loans
- Each loan has face value of 100
- The probability of default for each loan is 0.1
- The recovery rate is 0
- The loans are from various different borrowers across different industries

A credit derivative is written on this portfolio. The credit derivative reimburses the protection buyer for the loss of the loan portfolio if the total loss is over 20,000.

You use single factor Gaussian copula to model the joint default probability of the loans. Let Y_n be the creditworthiness index of the loan n.

$Y_n = \beta Z + \sqrt{1-\beta^2}\varepsilon_n$ where $Z \; and \; \varepsilon_n$ are independent N(0,1) random variables, $\beta = 0.1$

(b) (*1 point*) Calculate the expected loss from the credit portfolio and the correlation between Y_n and $Y_{m,}$, for any n not equal to m.

ANSWER:

The market price of the credit derivative is 10,000. Your team is asked to analyze the market price of the credit derivative in comparison to the price of the derivative calculated using the Gaussian copula.

(c) (*2 points*) Explain why the Gaussian copula is not an appropriate method for calculating the market price of the credit derivative.

ANSWER:

12.

(*5 points*)

(a) (*1 point*) Critique the following statements with respect to risk for life insurance firms:

(i) Firm size has a significant impact on insurer risk.

(ii) Asset value can be used as a proxy for firm size.

ANSWER:

(b) (*1 point*) Describe additional factors that should be taken into consideration when assessing the systemic risk of insurers.

ANSWER:

Several empirical studies have focused on identifying the internal and external determinants of insurer risk.

(c) (*1 point*) Explain four of the important external risk indicators for life/health insurers.

ANSWER:

Asset-liability management for insurance companies often involves immunization strategies.

(d) (*1 point*) Describe two types of immunization strategies, including any limitations associated with each.

ANSWER:

12. Continued

In a broad portfolio of life and health insurance contracts, due to underlying mortality and morbidity assumptions, claim sizes and the timing of cash flows can be predicted fairly well. However, there are factors that could lead to false predictions of life insurance liabilities.

(e) (*1 point*)

(i) Identify the factors that could lead to this false prediction.

ANSWER:

(ii) Describe how the immunization strategy goal can be defined to help address this.

ANSWER:

13.

(*5 points*) Company ABC is the plan sponsor for a non-contributory defined benefit pension plan.

The asset management of the pension fund, outsourced to a third-party manager, is invested in government bonds and collateralized loan obligations (CLO). The investment in high-rated CLO was justified to match the retirement liability payments that have duration of about 20 years at the time of retirement.

The pension committee has expressed concern about the credit risk surrounding their investments with the growing number of new retirees.

(a) (*1.5 point*) Describe the exposure to credit risk and the source of credit risk for each party involved in the pension plan.

ANSWER:

The investment policy uses ratings from major rating agencies for its credit risk limits for all fixed income instruments.

(b) (*1 point*) Explain three drawbacks of relying on these ratings.

ANSWER:

(c) (*1.5 points*) Explain the appropriateness of using CLOs to support pension plan liabilities.

ANSWER:

To mitigate its risk exposure to asset default, ABC is considering entering into a contract with an insurance company. The contract pays the pension fund an income equal to the benefits of the members covered in exchange for a lump sum.

(d) (*1 point*) Describe the credit risk exposure created by the above contract for ABC.

ANSWER:

14.

(*6 points*) You are a consultant retained by Company MGC, a life and annuity insurance company that doing an internal review of its Asset Liability Framework and developing its first formal Investment Policy Statement (IPS). You are given:

- MGC is an industry leader in Whole Life insurance
- MGC has implemented several portfolio management concepts over time
- MGC has done extensive work understanding and describing its client(s) and all relevant parties and their duties while also establishing a clearly defined purpose
- MGC has documented appropriate investment goals and constraints along with explaining the investment strategies it utilizes

(a) (*2 points*)

(i) (*1 point*) Explain what MGC's portfolio management documentation is missing that an IPS would add.

ANSWER:

(ii) (*1 point*) Explain how a formal IPS adds value to MGC

ANSWER:

14. Continued

You are given the following information about MGC's assets and liabilities:

- Asset Duration = 10 years
- Liability Duration = 10 years
- Total Assets = $10 Billion
- Total Surplus = $950 Million
- Weighted average credited rate of MGC's policies: 5%
- MGC's current portfolio yield: 4.53%
- Current 10-year Treasury rate: 3%

You are now working on reviewing MGC's investment strategy. One of the stated objectives in MGC's current investment document says:
"The investment strategy should support the company's policyholder liabilities while maintaining regulatory compliance."

The head of investments at MGC drafts a high-level proposal of the reallocation as follows:

Asset Class	Regulatory Surplus Charge*	Expected Yield	Current Allocation	Proposed Allocation
Investment Grade Bonds	2.00%	3.50%	65%	30%
High Yield Bonds	10.00%	6.00%	10%	10%
Structured Assets	2.50%	5.00%	5%	20%
Real Estate	5.00%	6.00%	10%	10%
Common Stock	45.00%	8.00%	10%	20%
Private Equity	50.00%	14.00%	0%	10%
Total			100%	100%
Weighted Expected Yield-->			4.53%	
Regulatory Surplus Charge-->			7.43%	
Total Surplus Charge = Weighted Surplus Charge(%)*Total Assets-->			742,500,000	

*Regulatory Surplus Charge represents the additional capital expected per asset class to maintain regulatory compliance

14. Continued

(b) (*2 points*)

(i) (*1 point*) Analyze the proposed investment strategy considering MGC's stated objectives

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

(ii) (*1 point*) Construct a revised portfolio, starting with the "Current Allocation," and making exactly two 5% adjustments from one asset class into another that meets MGC's goals.

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

As you've been working with MGC, inflation has increased significantly resulting in the Federal Reserve raising interest rates —the 10-year treasury rate is now 7%. MGC is interested in the impact rising interest rates may have on its business.

(c) (*2 points*)

(i) (*1 point*) Explain how the current economic situation impacts MGC.

ANSWER:

(ii) (*1 point*) Describe two actions MCG can take to mitigate its risk.

ANSWER:

****END OF EXAMINATION****