

Exam ILALAM

Date: Friday, May 3, 2024

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 6 questions numbered 1 through 6 with a total of 60 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.

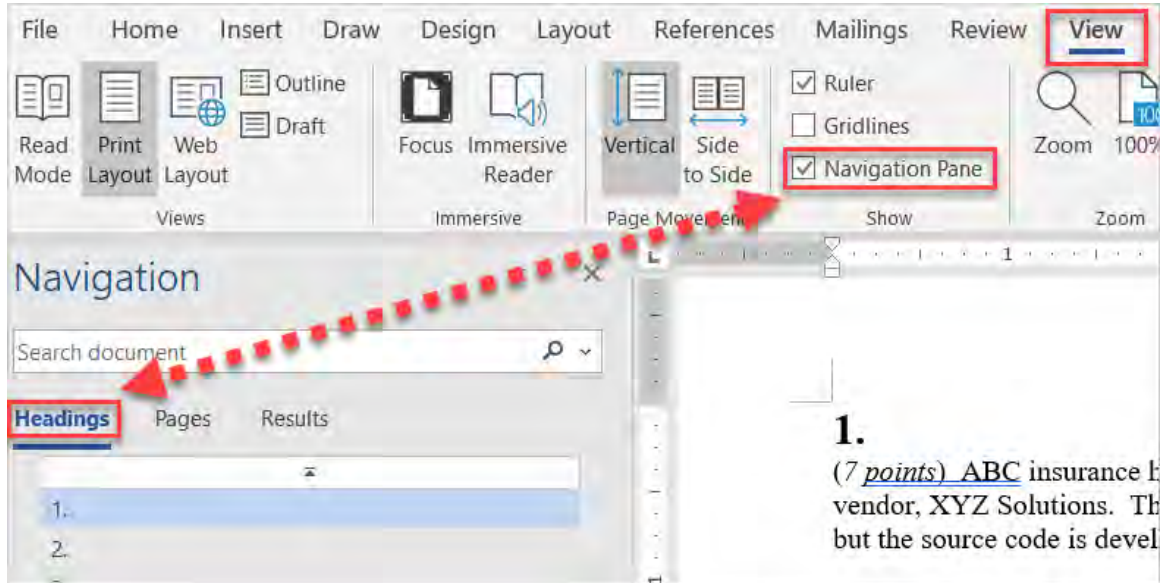
Written-Answer Instructions

1. Each question part or subpart should be answered either in the Word document or the Excel document as directed within each question. Graders will only look at work in the indicated file.
 - a) In the Word document, answers should be entered in the box marked ANSWER within each question. 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 X^2 can be typed as x^2.
 - b) In the Excel document formulas should be entered. For example, $X = \text{component1} + \text{component2}$. 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 documents that contain your answers must be uploaded before time expires.

Navigation Instructions

Open the Navigation Pane to jump to questions.

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



1.

(8 points) Your company is reviewing and updating various models used across the organization.

(a) (2 points) Critique the following statements regarding stochastic modeling:

A. *Stochastic models should only be used when it is explicitly required by a regulatory standard.*

ANSWER:

B. *Real-world scenarios cannot be connected with risk-neutral scenarios due to different usage of expected cash flows and a discount rate.*

ANSWER:

C. *For nested stochastic modeling, real-world scenarios and risk-neutral scenarios should be used for inner-loop and outer-loop, respectively.*

ANSWER:

D. *When using a random number generator, a true random number generator is more efficient than a pseudo random number generator.*

ANSWER:

1. Continued

- (b) (3 points) A Generalized Linear Model (GLM) is due for an update. The following data is provided regarding claim severity:

	Smoker	Non-smoker
Male	900	500
Female	600	400

The form of the GLM is:

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

Where:

β_1 = Parameter for Male

β_2 = Parameter for Female

β_3 = Parameter for Smoking Status

- (i) (2 points) Solve for parameters β_1 , β_2 and β_3 assuming the error term is normally distributed with mean zero and variance σ^2 .

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

- (ii) (1 point) Evaluate the limitations of the use of a normal error structure.

ANSWER:

- (c) (3 points) Your company uses a normal distribution with constant volatility to project equity returns.

- (i) (1 point) Describe a drawback of using the normal distribution with constant volatility to project returns.

ANSWER:

- (ii) (2 points) Recommend two possible alternatives to using constant volatility. Justify your answer.

ANSWER:

2.

(11 points) Company AH has a deterministic liability-only modeling system for its annuity block with the following characteristics:

- It is a locked-down system driven by built-in functionality and switches.
- Vendors play a critical role in system maintenance. They make improvements to the modeling system and update system documentation.

(a) (4 points) Critique the following statements about the modeling system at company AH:

A. *The robust documentation the vendor provides should provide sufficient details for the company to gain understanding of the actuarial calculation methodology programed in the system.*

ANSWER:

B. *Since the calculations are controlled and locked in, risk of illogical calculation is minimal, and the company can rely heavily on the integrity of the system.*

ANSWER:

C. *Since vendor coders are professional programmers, they have deep expertise in code optimization that results in faster model runs. This gives the company very good control over model efficiency and runtime.*

ANSWER:

D. *Key-person risk is increased with the platform since only a small group of modelers have a detailed understanding of the model and the history of code development. Parameters can sometimes be cryptic, and workarounds incorporated to accommodate rigid aspects of the system.*

ANSWER:

2. Continued

Company AH is preparing for annual cash flow testing on their annuity block. In accordance with best practices, they validate their model prior to using the results. The following table is the liability static validation as of December 31, 2023:

		Variable Annuity			Fixed Indexed Annuity		
		Extract	Model	Validation	Extract	Model	Validation
Policy Values	Count	3,212	3,212	100.0%	1,422	1,311	92.2%
	Premiums	4,532,331	4,532,331	100.0%	1,443,678	1,302,631	90.2%
	Account Value	277,448,507	275,783,816	99.4%	88,375,343	80,598,313	91.2%
	Cash Value	264,236,673	263,708,200	99.8%	84,166,993	76,676,131	91.1%
Reported Amounts	Stat Reserves	266,879,040	266,078,403	99.7%	118,274,306	98,285,948	83.1%
	Tax Reserves	266,689,054	266,422,365	99.9%	109,770,383	92,316,892	84.1%
	Target Surplus	16,567,889	16,518,185	99.7%	7,342,486	5,763,851	78.5%

- (b) (3 points) Identify three areas where additional investigation may be required based on the liability static validation result summary above. Justify your answer.

ANSWER:

- (c) (1 point) Critique the following statements regarding static validation:

- A. *Desired tolerance % should be determined first and be used consistently across all bases.*

ANSWER:

- B. *It is reasonable to expect a model to represent the entire block of business well.*

ANSWER:

2. Continued

(d) (3 points) Company AH uses a stochastic model to model the asset risk for this annuity block. Management is implementing the Transfer Scenario Order model efficiency technique to reduce runtime on a CTE 70 calculation.

(i) List the steps needed to use this technique.

ANSWER:

(ii) Calculate the runtime reduction percentage achieved based on the data provided below:

	Policies	Scenarios	Runtime (h)
Original	25,000	1,000	380
New Run 1	1,250	1,000	19
New Run 2	20,000	400	152

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

3.

(11 points) RXZ Life sells a fixed deferred annuity with the following features:

- Accumulation period is 10 years.
- Fund value is credited a fixed interest rate.
- The fixed interest rate is set equal to the market rate when the policy is sold.
- Additional premiums can be paid during the accumulation period.
- Policyholders can make partial withdrawals during the accumulation period.
- Withdrawals are subject to a surrender charge that decreases by duration.

The assets backing this product are 10-year bonds whose yield provides a target spread relative to the fixed crediting rate.

- (a) (1 point) Explain how a life insurance product is viewed differently by capital market practitioners and actuaries.

ANSWER:

- (b) (2 points)

- (i) Identify the option(s) granted to policyholders in this annuity product. Justify your answer.

ANSWER:

- (ii) Assess how changes in the interest rate environment can trigger policyholders to exercise the options described in (i).

ANSWER:

3. Continued

- (c) (5 points) In response to the volatile interest rate environment, RXZ seeks to better manage their embedded option risk. As a risk mitigant, RXZ decides to change the fixed crediting rate to a floating rate based on SOFR.

- (i) (1 point) Describe how LIBOR and SOFR are determined.

ANSWER:

- (ii) (2 points) Contrast the advantages of using LIBOR and SOFR. Justify your answer.

ANSWER:

- (iii) (2 points) Propose two changes in product design RXZ can make to mitigate the embedded option risk.

ANSWER:

- (d) (3 points) Below is a summary of monthly transactions and account values for a newly issued annuity policy:

Transaction Item	Day	Value
Initial deposit	1	100,000
Policy charges / fees	1	150
Interest credited	15	165
Additional deposit (after interest crediting)	15	10,000
Interest credited	30	250
End of period account value	30	110,265

- (i) Calculate the time-weighted investment return on the account for this month. Show all work.

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

- (ii) Estimate the money-weighted investment return on the account for this month. Show all work.

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

4.

(8 points) You are an actuarial consultant hired by ABC to perform cash flow testing (CFT). You are given the following information about ABC:

- ABC is an AA rated insurer domiciled in the USA.
- ABC primarily sells fixed rate deferred annuities.
- ABC does not include defaulted bonds in asset modeling.
- ABC's asset portfolio is based on a "bullet" structure with investment-grade bonds.

(a) (2 points) Evaluate if the bullet structure is appropriate for managing asset liability mismatch risk. Recommend changes if needed. Justify your answer.

ANSWER:

(b) (4 points) Critique the following proposals from ABC's management:

A. *Given ABC's high credit rating, the annuities we sell also carry the same high rating. By investing the annuity premiums in junk bonds, we have effectively arbitrated a spread on the transaction.*

ANSWER:

B. *For modeling simplicity, we can use the same credit rating transition to project default losses for both investment-grade and high-yield bonds.*

ANSWER:

C. *We should include defaulted bonds in asset modeling.*

ANSWER:

D. *We can take advantage of falling interest rates by selling older, higher yielding bonds to realize the gains and help boost our reported earnings.*

ANSWER:

4. Continued

(c) (2 points) ABC is considering reinsuring a few large blocks of business via a modified coinsurance agreement.

(i) Assess whether CFT should be performed on the reinsured blocks. Justify your answer.

ANSWER:

(ii) Recommend whether the reserves of the reinsured blocks should be included in the asset adequacy analysis when preparing the Actuarial Opinion and Memorandum Regulation (AOMR) for ABC.

ANSWER:

5.

(11 points) You are developing an economic scenario generator (ESG) to be used to model interest rates for hedging a block of variable annuities.

(a) (4 points) Critique the following statements:

A. *Interest rate modeling is not as complex as stock price modeling as the term structure of interest rates only requires modeling a single variable.*

ANSWER:

B. *It is not sufficient to treat the risk-free rate as a fixed parameter. An ESG that is being used for the management of variable annuity risk would need to include model dynamics that capture the path wise features of interest rates.*

ANSWER:

C. *Arbitrage-free models are a necessary requirement when one wants to apply an ESG to real-world scenarios. If the scenarios are not arbitrage-free, then one cannot consistently price derivatives.*

ANSWER:

D. *Only risk-neutral scenarios are used for hedging variable annuities.*

ANSWER:

(b) (1 point) Describe the purpose of establishing Stylized Facts prior to the development of the ESG.

ANSWER:

5. Continued

Management is not convinced about the use of an ESG and recommends using analytical solutions which do not require intensive computation.

- (c) (2 points) Critique management's recommendation.

ANSWER:

The company sells a variable annuity with a guaranteed minimum accumulation benefit (GMAB). You are given:

Risk-free interest rate	3%
Account value	100,000
Guarantee value	100,000
Ratchet	Annual
Maturity	10 years

The account value will either increase or decrease by 8% each year. Assume no other fees, decrements, or expenses.

- (d) (2 points) Calculate the risk neutral probability of the account value increasing by 8% in a given year.

<i>The response for this part is to be provided in the Excel spreadsheet.</i>

5. Continued

(e) (2 points) State if the following concepts are illustrated in the model used in part (d). Justify your answer.

(i) Replication

ANSWER:

(ii) No-arbitrage assumption

ANSWER:

(iii) Risk neutral probability distribution

ANSWER:

(iv) Dynamic hedging

ANSWER:

6.

(11 points) Your company sells universal life policies with minimum interest rate guarantees in a saturated and competitive market. Senior management has stated solvency is one of their primary concerns given the company stock was recently downgraded.

(a) (2 points)

(i) Describe the return objectives and risk tolerance for the company's investment policy statement.

ANSWER:

(ii) Identify four investment constraints the company should consider when managing their portfolio.

ANSWER:

The following is the company's current asset allocation strategy:

Asset Class	Target Allocation	Permissible Range
Treasury bonds	25%	20% - 40%
Bonds (municipal and corporate)	25%	20% - 40%
Equities (domestic, international, and mortgages)	20%	10% - 30%
Commercial paper	15%	5% - 25%
Cash	15%	5% - 25%

Your manager believes the asset allocations should be adjusted over time as the market shifts.

(b) (2 points) Assess the asset allocation strategy.

ANSWER:

6. Continued

(c) (4 points) Critique each of the following statements for structuring a portfolio:

A. *You can evaluate and identify assets with misaligned credit ratings to build a portfolio that will outperform a benchmark.*

ANSWER:

B. *The assets purchased should be matched to the average duration of the liabilities. By doing this, it will protect against all changes in the market yield curve.*

ANSWER:

C. *A portfolio should be built to track a benchmark index. This can reduce fees compared to investing in the assets that are part of the index directly. Given it is unlikely the portfolio will perfectly track the index, the focus for selecting assets should be on expected returns.*

ANSWER:

D. *Interest rate swaps can help reduce interest rate risk and improve returns. You can also consider buying forwards for specific points in the future as an alternative.*

ANSWER:

6. Continued

- (d) (3 points) The company is evaluating bonds to add to the portfolio that backs a 10-year liability. Prevailing market interest rates are increasing and expected to continue to rise. You are given the following information:

Bond	Coupon Rate	Coupon Frequency	Term (years)	Yield to Maturity	Maturity Value
Bond 1	11%	Semi-annual	10	5.0%	\$1,000
Bond 2	7%	Semi-annual	20	6.1%	\$1,000
Bond 3	0%	N/A	15	2.2%	\$1,000
Bond 4	6%	Semi-annual	5	8.4%	\$1,000

- (i) (1 point) Calculate the price of each bond.

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

- (ii) (2 points) Recommend a bond to add to the portfolio from the options above. Justify your answer.

ANSWER:

****END OF EXAMINATION****