

# Exam ILALAM

**Date:** Friday, May 5, 2023

## INSTRUCTIONS TO CANDIDATES

### General Instructions

1. This examination has 8 questions numbered 1 through 8 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.

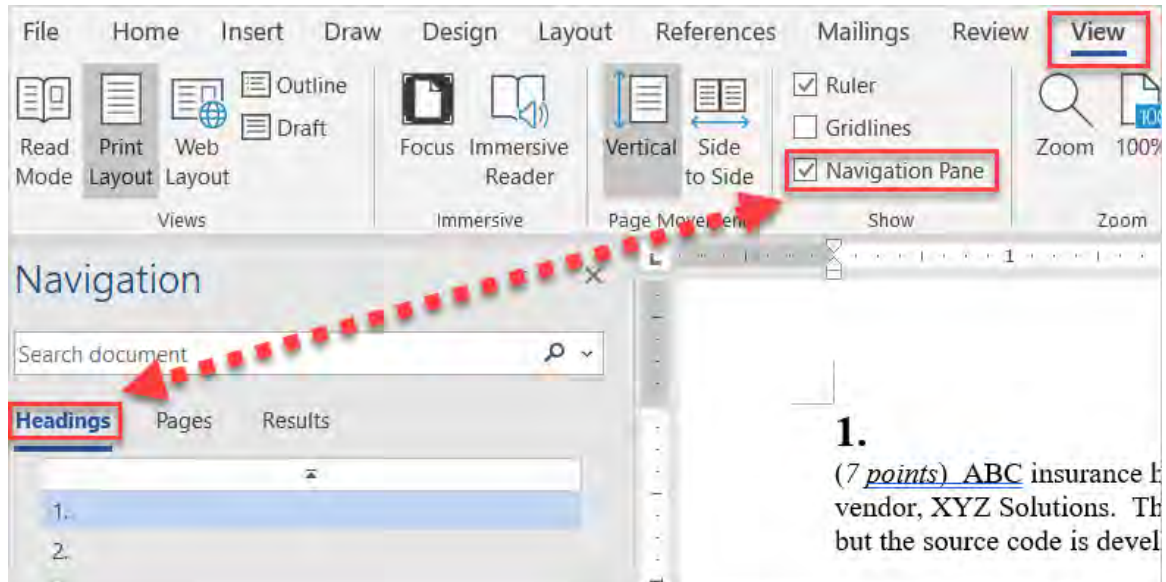
### Written-Answer Instructions

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,  $\beta_1$  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.

(10 points) You have been asked to assess the impact of various economic scenarios on your company's assets or liabilities.

- (a) (5 points) For each scenario listed below:
- (i) Assess the impact on your company
  - (ii) Recommend a risk mitigation strategy if appropriate
  - (iii) Discuss any potential disadvantages of the risk mitigation strategy proposed in (ii)

	<b>Economic Scenario</b>	<b>Asset / Liability</b>
A	High Inflation	Whole Life Insurance with a fixed policy loan rate
B	Deflation	Universal Life with minimum crediting rate guarantee
C	Rising Interest Rates	Universal Life with minimum crediting rate guarantee
D	High Inflation	Fixed annuities with cost-of-living adjustments indexed to inflation
E	High Inflation	Long-term fixed bonds

ANSWER:

## 1. Continued

- (b) (3 points) You have been asked to review your company's Economic Scenario Generator (ESG) regarding its suitability to simulate future interest rate paths including inflation.

Critique the following statements:

- A. *The applications of the ESG are primarily focused on the interaction of interest rate changes and policyholder behavior so its use is limited to liability valuation. It is not suitable for stress testing.*

ANSWER:

- B. *To model the relationship between inflation and interest rates your company uses parameters based on historical inflation data from the last 30 years.*

ANSWER:

- C. *For calibrating the parameters within an ESG, making use of a cascade structure where interest rates are at the top of the cascade with inflation below would imply that interest rate changes cause inflation.*

ANSWER:

- (c) (2 points) Identify four relevant recommended practices from ASOP 56, *Modeling*, that should be considered when relying on external experts to develop your company's ESG.

ANSWER:

## 2.

(10 points) FGE Life sells term and whole life policies with a portfolio of assets backing the liabilities. The following data is for a benchmark portfolio consisting of 4 bonds of equal par amounts.

<b>Bond</b>	<b>Market Value</b>	<b>Duration</b>
Bond 1	78,215	4.102
Bond 2	80,777	4.979
Bond 3	81,030	1.831
Bond 4	89,936	2.865

One year later, the bond market values have changed due to yield curve movement.

<b>Bond</b>	<b>Market Value</b>	<b>Duration</b>
Bond 1	76,189	3.422
Bond 2	75,921	4.089
Bond 3	76,733	0.967
Bond 4	91,004	1.760

(a) (4 points)

- (i) (3 points) Calculate the cash required for rebalancing to maintain the initial portfolio dollar duration. Show all work.

*The response for this part is to be provided in the Excel document*

- (ii) (1 point) Discuss considerations when rebalancing a portfolio when using an immunization strategy.

ANSWER:

FGE Life has a low risk tolerance and is reviewing the company's investment strategy in response to poor returns.

(b) (4 points) Critique each of the proposed changes to FGE's investment strategy:

A FGE will use a dynamic asset liability approach

ANSWER:

## 2. Continued

*B FGE will change its current target allocation of 75% fixed income/15% equities/10% cash to a new target allocation of 20% fixed income/75% equities/5% cash*

ANSWER:

*C FGE will use a strategic asset allocation to exploit short term opportunities in the market*

ANSWER:

*D FGE will offer bonuses to portfolio managers who are able to identify strategies that improve returns*

ANSWER:

FGE is considering the following four possible asset allocations:

<b>Asset Allocation</b>	<b>Expected Return</b>	<b>Standard Deviation</b>
A	4%	5%
B	7%	30%
C	6%	8%
D	6.5%	10%

FGE has a risk aversion value of  $R_A = 6$  (low risk tolerance). The current portfolio value is 50 million, and the company wants to invest 2 million into launching a new product next year without depleting the original principal.

(c) (2 points) Recommend which asset allocation FGE should choose, using Roy's safety-first criterion. Show all work and justify your answer.

*The response for this part is to be provided in the Excel document*

### 3.

(11 points) Following a recent recession your company is reviewing their asset liability management (ALM) practices and is considering implementing a strategic asset allocation (SAA) process.

(a) (5 points) Critique the following statements:

- A. *Given our company's historical success when limiting duration mismatch to within 0.5 years and limiting portfolio exposure to alternative assets to 10%, we will hold these constraints constant as we explore SAA.*

ANSWER:

- B. *Adding new asset classes will allow us to better diversify risks and optimize efficiency by considering possible correlations between various asset classes and correlations with our liabilities.*

ANSWER:

- C. *When building a replicating portfolio, we should prioritize matching the key rate duration (KRD) profile of liabilities instead of focusing only on minimum interest rate guarantees.*

ANSWER:

- D. *Given surplus volatility was the most severe impact of the recent recession, the SAA process will focus only on minimizing surplus volatility.*

ANSWER:

- E. *With an objective of closely matching the cash flows or interest rate duration of our liabilities, we maintain a separate investment portfolio to back the reserves for each of our major liability types.*

ANSWER:

### 3. Continued

- F. *A model should be built which seeks to maximize return for a given level of surplus volatility while factoring in our chosen constraints. This will provide an efficient frontier that can be used to determine our risk appetite.*

ANSWER:

Your company is reviewing an annuity product which provides policyholders level annual annuity payments for the next 10 years. The company plans to invest evenly between 5-year and 10-year zero coupon bonds to back this liability.

You are provided with three yield curve shocks and liability portfolio key rate durations (KRD).

Yield Curve Shocks (in basis points):

	1 yr	2 yr	3 yr	4 yr	5 yr	6 yr	7 yr	8 yr	9 yr	10 yr
Shock 1	25	25	25	25	25	25	25	25	25	25
Shock 2	70	66	55	33	0	25	35	45	55	65
Shock 3	-75	-55	-35	-15	-10	-1	10	25	45	55

Liability Portfolio KRD:

	1 yr	2 yr	3 yr	4 yr	5 yr	6 yr	7 yr	8 yr	9 yr	10 yr
KRD	0.1	0.3	0.7	0.9	1.2	1.4	1.5	1.1	0.3	0.2

Assume the asset and liability values are 100 million at time zero.



### 3. Continued

(b) (6 points)

(i) Calculate the change in surplus under each shock. Show all work.

*The response for this part is to be provided in the Excel document*

(ii) Assess if the investment strategy immunizes the company's surplus.

*The response for this part is to be provided in the Excel document*

(iii) Identify key considerations if implementing a liquidity risk policy for this product.

ANSWER:

#### 4.

(5 points) Your company offers a 2-year Guaranteed Minimum Accumulation Benefit (GMAB) rider on a Variable Annuity (VA). You are given:

<b>Risk Free Interest Rate</b>	6%
<b>Account Value (0)</b>	10,000
<b>GMAB (0)</b>	10,000
<b>Ratchet</b>	Annual
<b>Maturity</b>	2-years

The account value will either increase by 15% or decrease by 10% each year. Assume no other fees, decrements, or expenses.

- (a) (1 point) Calculate all GMAB claims at the end of year 2.

*The response for this part is to be provided in the Excel document*

- (b) (2 points) Calculate the risk neutral probability of the account value decreasing 10% in a given year.

*The response for this part is to be provided in the Excel document*

- (c) (2 points) Calculate the cost of hedging the GMAB rider at issue.

*The response for this part is to be provided in the Excel document*

## 5.

(7 points) XYZ Life is developing a Monte Carlo model to simulate stochastic claims for a fully underwritten block of term life insurance.

- (a) (2 points) Compare the use of True Random Number Generators and Pseudo Random Number Generators as a source of randomness in a stochastic model.

ANSWER:

XYZ recently completed a study on mortality experience and makes the following assumptions in their deterministic model:

- Base Mortality Rate – the study lacked the desired credibility level due to a limited number of claims, so a margin was added to the base mortality table as a measure of conservatism.
- Mortality Improvement Rate – the historical mean mortality improvement rate from the past 30 years is assumed to apply for all ages.
- Catastrophic Mortality – a bulk amount is held on a best estimate basis.

- (b) (3 points)

- (i) Identify how stochastic modeling could improve each deterministic mortality parameter.

ANSWER:

- (ii) Describe an approach which could be used to model each parameter stochastically.

ANSWER:

XYZ's ALM Department ran 50 simulations and provided the net present value (NPV) of Death Benefits for each scenario. Management proposes holding capital of 400 million in addition to the average NPV of death benefits. The data is provided in the excel file.

- (c) (2 points) Assess if the proposed capital amount is sufficient to cover expected losses at the 90<sup>th</sup> percentile. Justify your answer.

*The response for this part is to be provided in the Excel document*

**6.**

(6 points) Your company has contracted with MYB Solutions to provide actuarial modeling software. MYB is responsible for periodic updates to core calculation functionality. Your company is considered an end-user and has access to input, output, and reporting functions.

(a) (4 points) Critique each statement in the context of Model Risk Management and ASOP 56, Modeling.

A. *Your management team suggests to fully rely on MYB for modeling expertise as they control the functionality and are responsible for updating the calculation engines.*

ANSWER:

B. *To assess usefulness of the report you decide to survey a group of actuaries who use the report for their feedback.*

ANSWER:

C. *To mitigate third party risk your company has applied a margin of conservatism to the mortality table*

ANSWER:

D. *MYB failed to deliver your stress testing model on time. As a result, your risk department is repurposing a pricing model to conduct their regulatory reporting*

ANSWER:

**6. Continued**

MYB provides a user guide for the software that has detailed instructions on how the model functions and descriptions of the features available to the end-users.

- (b) (2 points) Identify additional documentation required from MYB and your company to ensure effective model risk control.

ANSWER:

## 7.

(6 points) Your company sells an Equity Indexed Annuity (EIA) and a Variable Annuity (VA) with a Guaranteed Minimum Maturity Benefit (GMMB). The products are designed as follows:

	<b>EIA</b>
Single Premium	100,000
Maturity	5 years
Underlying Investment	S&P 500
Ratchet	Compound Annual
Annual Equity Return Cap	10%
Annual Equity Return Floor	2%
Participation Rate	90%
Guaranteed Minimum Annual Interest Rate on Single Premium	4%

	<b>VA with GMMB</b>
Single Premium	100,000
Maturity	5 years
Underlying Investment	S&P 500
GMMB	100% of Single Premium
Management Fee (Collected at end of year)	6%

Assuming the VA is held to maturity, the pricing department expects it will generate 10,000 of profit if the S&P Index earns 5% per year. This profit estimate includes the cost of hedging the GMMB with an at-the-money put option maturing at time 5.

- (a) (2 points) Calculate the cost of hedging the GMMB in the pricing model. Show all work.

*The response for this part is to be provided in the Excel document*

The risk department plans to hedge the EIA by investing the single premium as follows:

- Purchase an at-the-money call option maturing at time 5
- With the remaining funds, purchase a zero-coupon bond earning the guaranteed minimum rate specified in the product design

## 7. Continued

You are given the following market parameters:

S&P 500 Return: Year 1 – 4	5%
S&P 500 Return: Year 5	-50%
Risk Free Interest Rate	3%

Assume no other fees, expenses or decrements.

- (b) (4 points) Calculate the profit or loss generated by the EIA

*The response for this part is to be provided in the Excel document*

## 8.

(5 points) Insurance Company HLC has collected data on claims experience. A Generalized Linear Model (GLM) used to predict claim frequencies is constructed using a log link, resulting in the following estimated coefficients:

Predictor Variables	Coefficients
Intercept	3.2
Issue Age	0.02
Gender (1 for Male, 0 for Female)	0.1
Smoking Status (1 for Non-Smoker, 0 for Smoker)	-0.4

(a) (2 points) Compare each of the following components when implementing a linear model versus a generalized linear model:

- Random Component
- Systematic Component
- Link Function

ANSWER:

(b) (2 points) Calculate the expected claim frequency for a 35-year-old male smoker. Show all work.

*The response for this part is to be provided in the Excel document*

(c) (1 point)

(i) Describe challenges a company may face when implementing a GLM

ANSWER:

(ii) Describes techniques which could be used to overcome these challenges

ANSWER:

**\*\*END OF EXAMINATION\*\***