SOCIETY OF ACTUARIES

Asset Liability Management

Exam CP-351

Date: Thursday, November 20, 2025

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 9 questions, numbered 1 through 9, with a total of 50 points.

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

2. 2. If a question asks for a recommendation, you must justify your answer

3. 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) For each question part requiring an answer in Excel, (1) clearly identify the inputs to the calculations, (2) show the necessary interim calculations, adding rows and / or columns, if necessary, and (3) enter the final answer in some or all of the cells highlighted in yellow, as applicable in each circumstance. These cells should contain formulas with links to other calculations in the worksheet. Minimize the use of hard-coded figures and maximize the number of interim steps in the calculations that would demonstrate your line of thinking.

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 instead use your candidate number.

4. The Word and Excel files that contain your answers must be uploaded before the five-minute upload period expires.

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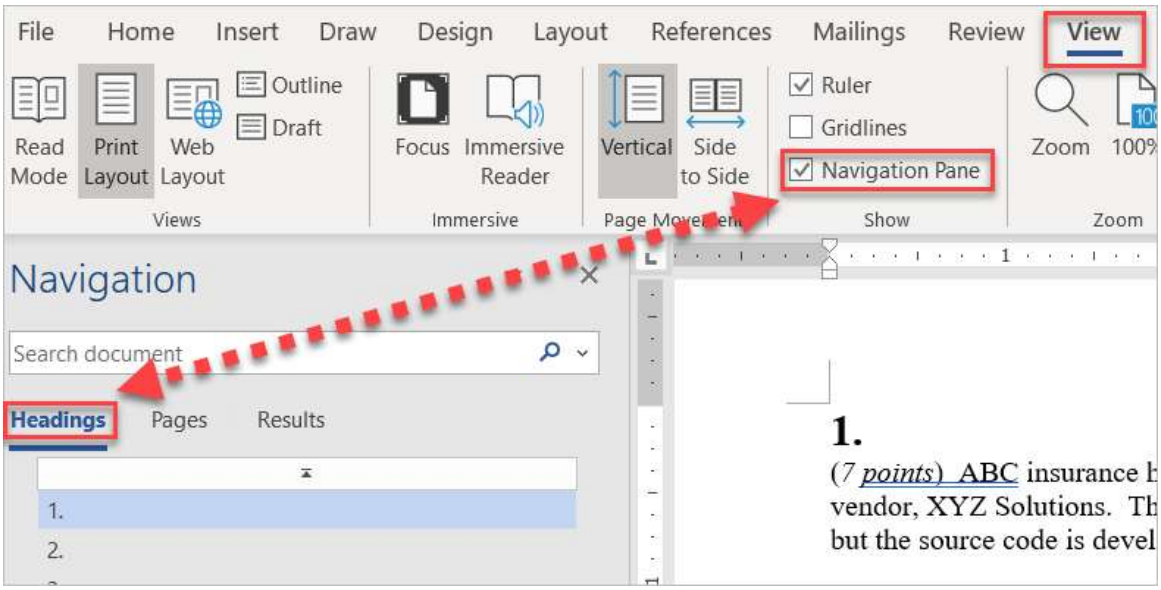
Navigation Instructions

Open the Navigation Pane to jump to questions.

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



1.

(*5 points*) You are an actuary at ABC Life, a company that sells long-duration life insurance products with guaranteed benefits. ABC Life primarily invests in fixed income securities to match its long-term liabilities.

ABC Life's Chief Risk Officer (CRO) states: "If we match the durations of our assets and liabilities, we will eliminate interest rate risk."

(a) (*1 point*) Critique the CRO's statement.

ANSWER:

The details of ABC Life's asset and liability portfolio are as follows:

- Assets: Duration = 8.5, Fair Value = $500 million
- Liabilities: Duration = 12.0, Present Value = $480 million

ABC Life wants to immunize its portfolio using dollar duration matching.

(b) (*1.5 points*)

(i) (*0.5 points*) Calculate the dollar duration mismatch.

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

(ii) (*1 point*) Recommend two ways ABC Life can address the duration mismatch.

ANSWER:

1. Continued

ABC Life's assets are heavily weighted in long-term government bonds to cover the guaranteed policyholder benefits.

(c) (*2.5 points*)

(i) (*1 point*) Describe two risks ABC Life faces in a falling interest rate environment.

ANSWER:

(ii) (*1.5 points*) Recommend three approaches for ABC Life to mitigate these risks.

ANSWER:

2.

(*5 points*) You are a risk consultant for a life insurance company that has a large block of legacy fixed annuity products that have passed their surrender charge periods.

The life insurance company wants to learn from historical failures in ALM, specifically the collapse of Long Term Capital Management (LTCM) in 1998. You are tasked with analyzing this case and providing recommendations to enhance the company's ALM framework.

LTCM initially focused on fixed income arbitrage within a single government bond market and later expanded to trading opportunities across different government bond markets.

(a) (*1.5 points*) Assess whether the following fixed income strategies of LTCM are true arbitrage:

(i) (*0.75 points*) Initial strategy within a single government bond market

ANSWER:

(ii) (*0.75 points*) Expanded strategy across different government bond markets

ANSWER:

A colleague claims that:

- LTCM's collapse was due to its over-leveraged positions in emerging market bonds, which became unprofitable when the Russian government defaulted on its debt in 1998.

- Silicon Valley Bank's collapse was triggered by its failure to hedge the interest rate risk on its long term Treasury bond portfolio, leaving it exposed to losses as rates rose in 2022-2023.

2. Continued

(b) (*2 points*) Critique the colleague's claims.

ANSWER:

(c) (*1.5 points*) Propose three improvements for the company's ALM practice based on lessons learned from these collapses.

ANSWER:

3.

(*5 points*) You are an actuary at LMN, a company domiciled in a country subject to IFRS 4. You are working to anticipate the impact of implementing IFRS 17 on an annuity product, whose cash flows extend beyond 50 years.

You are aware of the following differences in setting discount rates between IFRS 4 and IFRS 17:

- Under IFRS 4, liability discount rates are set based on the assets being held to back the liability.
- Under IFRS 17, liability discount rates are not linked to the assets themselves, but only certain market characteristics, such as the risk-free rate plus market liquidity premium. Changes in the asset portfolio would not impact the discount rate.

LMN currently invests in a portfolio with a significant allocation to below investment grade bonds and private assets that are illiquid and carry significantly higher yields than public investment grade securities.

LMN's current portfolio allocation is as follows:

Asset	Allocation Weight
Risk-free bond	4%
Public A-rated bond	16%
Public BBB-rated bond	10%
Private BBB-rated bond	35%
Private BB-rated bond	35%

IFRS 17 discount rate is equal to the risk-free rate plus the simple average of the illiquidity spreads of all investment grade assets.

The fixed income market yields are given as follows:

Rating	**AAA**	**AA**	**A**	**BBB**	**BB**
Public	6.5%	6.5%	7%	9%	15%
Private	7%	7.5%	8%	10.5%	20%

(a) (*1 point*) Calculate the IFRS 4 and IFRS 17 liability discount rates for LMN.

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

3. Continued

(b) (*1 point*) Explain how the change in discount rate impacts the economic and accounting surplus of LMN.

ANSWER:

You are given the following table about the estimated annuity present value at various discount rates:

Discount Rate	5.5%	6.5%	7.5%	8.5%	9.5%
Annuity Present Value	133.3	117.6	105.3	95.2	87.0

Assume that, currently, LMN has the fair value of assets equal to the present value of the liabilities, with the following duration and convexity:

Duration	8.9
Convexity	60

LMN defines interest rate risk as the loss of surplus due to a 100 bps shock to the discount rate.

(c) (*1 point*) Calculate the interest rate risk on an accounting basis after the change to IFRS 17.

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

In the first quarter following the change to IFRS 17, the fixed income market yields change to the following:

Rating	**AAA**	**AA**	**A**	**BBB**	**BB**
Public	5.5%	7%	8%	10%	20%
Private	5.5%	7.5%	8.5%	11%	25%

3. Continued

(d) (*2 points*) Compare the impact on each of the following risk metrics under IFRS 4 vs. IFRS 17:

(i) (*1 point*) Sensitivity of surplus

ANSWER:

(ii) (*1 point*) Duration mismatch

ANSWER:

4.

(*6 points*) OPQ Insurance company sells long-term annuities backing pension obligations. The annuities pay a fixed amount until the policyholders die and contain no policyholder options. The annuities have significant cash flows that extend more than 25 years.

You are given the following corporate bond market data:

Maturity (Years)	1-5	6-10	11-15	16-30
Total size	$100,000	$50,000	$26,000	$5,000
Duration	2	7	10	14
Convexity	10	50	110	250
Spread over the risk-free rate	1.25%	2.00%	3.00%	4.50%
Credit spread	0.125%	0.30%	0.50%	1.00%

There exists a government bond market as well, whose bonds all carry the same risk-free rate of 5% and can be purchased with ample liquidity out to 30-year maturities. There also exists an equity market.

OPQ's annuity blocks have the following present values of projected cash flows (CF) based on various discount rates:

Discount Rate	CF from years 1-10	CF from years 11-15	CF from years 16-30	CF from years 31+	Total
5.00%	27,249	4,234	3,487	199	35,169
5.25%	26,978	4,108	3,323	183	34,592
5.50%	26,712	3,986	3,167	169	34,034
6.50%	25,689	3,535	2,620	122	31,966
6.55%	25,639	3,514	2,595	120	31,868
6.60%	25,590	3,493	2,571	118	31,772
6.80%	25,395	3,411	2,476	111	31,393
7.00%	25,202	3,331	2,385	104	31,022

The discount rate is equal to the risk-free rate of 5% plus the weighted average illiquidity spread in the market.

4. Continued

(a) (*2 points*) Calculate the following:

(i) (*0.5 points*) The liability discount rate

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

(ii) (*0.5 points*) Duration of OPQ's liabilities

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

(iii) (*1 point*) Convexity of OPQ's liabilities

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

(b) (*1 point*) Describe the challenges for OPQ in managing the interest rate risk of the liabilities using only corporate bonds.

ANSWER:

(c) (*1 point*) Recommend two methods OPQ could use to manage interest rate risk on the long-term annuity liabilities.

ANSWER:

OPQ is considering a carve-out strategy to manage their annuity liabilities.

(d) (*2 points*)

(i) (*1 point*) Explain what a carve-out strategy is.

ANSWER:

(ii) (*1 point*) Describe two advantages of a carve-out strategy for OPQ.

ANSWER:

5.

(*6 points*) You work for XYZ which sells life insurance products. As of yesterday morning, the following were true:

- The value of XYZ's assets was $2,500,000.
- The equity of XYZ was $450,000.
- The duration of assets matched the duration of liabilities exactly.

Yesterday at noon, there was a sudden, instantaneous drop in market interest rates of 150 basis points. Immediately after, as of 12:01 PM yesterday, your assistant used Monte Carlo simulations to estimate the value of XYZ's assets under 3 separate interest rate scenarios.

- Scenario A uses the spot curve from 12:01 PM yesterday.
- Scenario B uses a spot curve where all rates are 10 basis points higher than Scenario A.
- Scenario C uses a spot curve where all rates are 10 basis points lower than Scenario A.

The estimates for the total value of XYZ's assets produced by Scenario B and Scenario C are shown below:

Scenario	Estimated Value of Assets
B	2,583,800
C	2,637,300

The effective convexity of the asset portfolio is estimated to be 25 based on the simulations.

(a) (*1 point*) Estimate the value of the assets under Scenario A based on the results from the simulations.

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

5. Continued

Using the values before and after the drop in market interest rates and assuming that convexity is constant:

(b) (*3 points*) Estimate the following as of yesterday at 11:59 AM (before the drop in interest rates):

(i) (*1.5 points*) DV01 of XYZ's assets

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

(ii) (*1.5 points*) DV01 of XYZ's liabilities

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

After the shock in interest rates, your manager is concerned about the company's liquidity and calls for a meeting. During the meeting, your coworkers make the following statements.

> Coworker A: "Our company just recently completed a capital management framework, which showed that it has no issues maintaining its status as a going concern. Why do we need to implement a liquidity risk management framework?"
>
> Coworker B: "Our company needs to conduct a liquidity stress test. However, assets from separate accounts and closed blocks should be excluded."

(c) (*2 points*) Critique your coworkers' statements.

ANSWER:

6.

(*6 points*) Company UVW is launching a new general fund product, a life insurance contract where the net premiums are 100% guaranteed, and the policyholders can enter and exit the fund at any moment. The policyholders receive an annual benefit each year expressed as a crediting rate applied to the value of the contract.

Your team is conducting an ALM study on this product and collected the following information on the asset portfolio for year 2024:

- The strategic asset allocation of the product is 60% bonds and 40% equity.
- The average coupon rate of the bond was 5%.
- The realized average return of the equity was 8%.
- The equity turnover ratio was 20%.
- The equity dividend rate was 2%.

(a) (*1 point*) Calculate the financial return of the asset portfolio for the product in year 2024 based on the information above.

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

The Chief Investment Officer (CIO) wants to enhance the investment performance for year 2025 by optimizing the asset allocation. The CIO asks your team to generate the profits and risk by equity allocations and provides a sample below.

6. Continued

(b) (*1.5 points*)

(i) (*0.5 points*) Identify the efficient frontier on the sample plot above.

ANSWER:

(ii) (*1 point*) Describe the steps to generate the plot.

ANSWER:

Your manager asks you to calculate the crediting rate and profit sharing rate that will be paid by UVW to policyholders for year 2025 and sends you the following information:

- The target crediting rate of the product is set at 4%.
- UVW would like to limit the profit sharing rate between 0% and 3%.
- The profit sharing rate for year 2024 was 2%.

(c) (*2 points*) Calculate the crediting rate and profit sharing rate for the following two scenarios:

(i) (*1 point*) The expected financial return of the asset in year 2025 is 6%.

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

(ii) (*1 point*) The expected financial return of the asset in year 2025 is 1%.

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

Interest rates have recently increased. The product manager of UVW is concerned with the policyholder behavior risk for this product.

6. Continued

(d) (*1.5 points*) Describe the impact on policyholder behavior if UVW decides to:

(i) (*0.75 points*) Increase the crediting rate.

ANSWER:

(ii) (*0.75 points*) Keep the crediting rate at its current level.

ANSWER:

7.

(*8 points*) An insurance company has two blocks of annuity business:

- Product A: A 20-year fixed annuity that offers a crediting rate based on prevailing SOFR, with a minimum of 1.5% annually.
- Product B: A variable annuity where the account value grows based on a stock index and includes a Guaranteed Minimum Accumulation Benefit (GMAB) rider, so that the account value of the annuity is floored at the principal amount invested.

(a) (*1 point*) Describe the embedded options in each product from the perspective of the insurance company.

ANSWER:

(b) (*2 points*) Explain how two distinct interest rate derivatives can be used to mitigate the interest rate risk in Product A.

ANSWER:

The ALM team now plans to hedge the equity market risk associated with Product B. The equity risk of the product is linked to a stock index currently at $300. Through simulation, the team has obtained the following statistics of the liability:

Liability	**Dollar Delta**	**Dollar Gamma**
$ 2,200,000	- $57,750	$1,060

The ALM team plans to use the following two instruments to set up a static delta-gamma neutral hedging strategy at time 0:

Instrument	**Unit Price**	**Unit Delta**	**Unit Gamma**
Futures on the Index	$0	1	0
Put Option on the Index	$2.45	-0.093	0.0027

(c) (*2 points*) Calculate the number of units for each instrument and the total initial cost of setup.

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

7. Continued

After two months, the stock index has dropped from \$300 to \$270, and the price of the put option has increased to \$6.67. The ALM team runs the simulation again and finds that the liability has increased to \$4,400,000.

(d) (*2 points*)

(i) (*1 point*) Calculate the profit and loss after two months for the hedged portfolio in Part (c), including the initial setup cost.

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

(ii) (*1 point*) Assess whether the hedging strategy enhances the profitability for the company in this situation.

ANSWER:

The ALM team anticipates the upcoming economic landscape to be more volatile in the next few quarters. Your colleague suggests using a dynamic delta hedging strategy for Product B.

(e) (*1 point*) Critique your colleague's suggestion.

ANSWER:

8.

(*5 points*) GHI is a small life insurance company. You work in the risk management function and have been asked to set up stress testing.

You ask your colleagues for inputs on stress testing scenarios.

- Colleague A recommends focusing on interest rates as GHI's balance sheet has significant exposures to interest rates.
- Colleague B recommends using the stressed scenarios prescribed by the regulator.
- Colleague C recommends using only historical scenarios for stress testing.

(a) (*2 points*) Critique each colleague's recommendation.

ANSWER:

(b) (*0.5 points*) Identify three attributes that any stress scenario should possess.

ANSWER:

(c) (*1 point*) Compare top-down stress testing and reverse stress testing.

ANSWER:

8. Continued

GHI sells term life insurance contracts of 10 and 20 years.

(d) (*1.5 points*)

(i) (*0.5 points*) Describe a scenario for top-down stress testing.

ANSWER:

(ii) (*0.5 points*) Describe key inputs to GHI's risk models based on the scenario in Part (i).

ANSWER:

(iii) (*0.5 points*) Describe a scenario for reverse stress testing.

ANSWER:

9.

(*4 points*) RST's portfolio holds significant assets from Firm 1 and Firm 2. The management has asked you to study the impact of both firms defaulting. You are given the following information:

- The default of Firm i is modeled by a latent risk random variable X_i, $i = 1,2$.
- Firm i defaults if $X_i \leq 1$.
- $X \sim Exp(\lambda)$ means that X is a random variable following the exponential distribution, where $f_X(x) = \lambda e^{-\lambda x}, F_X(x) = 1 - e^{-\lambda x}$.
- $X_1 \sim Exp(0.05)$
- $X_2 \sim Exp(0.1)$
- RST will lose \$600 if only Firm 1 defaults, \$450 if only Firm 2 defaults, and \$1,700 if both firms default.

(a) (*0.5 points*) Calculate the marginal probability of default for each firm.

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

(b) (*1 point*) Calculate 99% Expected Shortfall of the loss given default, assuming X_1 and X_2 are independent.

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

Your manager asks you to incorporate Frank copula into the model. The Frank copula is defined by $C_{Frank}(u, v) = -a^{-1} \ln[1 + \frac{(e^{-au}-1)(e^{-av}-1)}{(e^{-a}-1)}]$, where a is a parameter.

(c) (*1 point*) Calculate the probability of both firms defaulting, assuming the dependency between X_1 and X_2 follows the Frank Copula with $a = 2$.

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

(d) (*1 point*) Calculate the 99% Expected Shortfall of the loss given default, assuming the dependency between X_1 and X_2 follows the Frank Copula with $a = 2$.

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

9. Continued

(e) (*0.5 points*) Explain the difference between the 99% Expected Shortfall computed in Part (b) and Part (d).

ANSWER:

END OF EXAMINATION*