

# Exam INV 101

Date: Tuesday, March 24, 2026

## 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. 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.

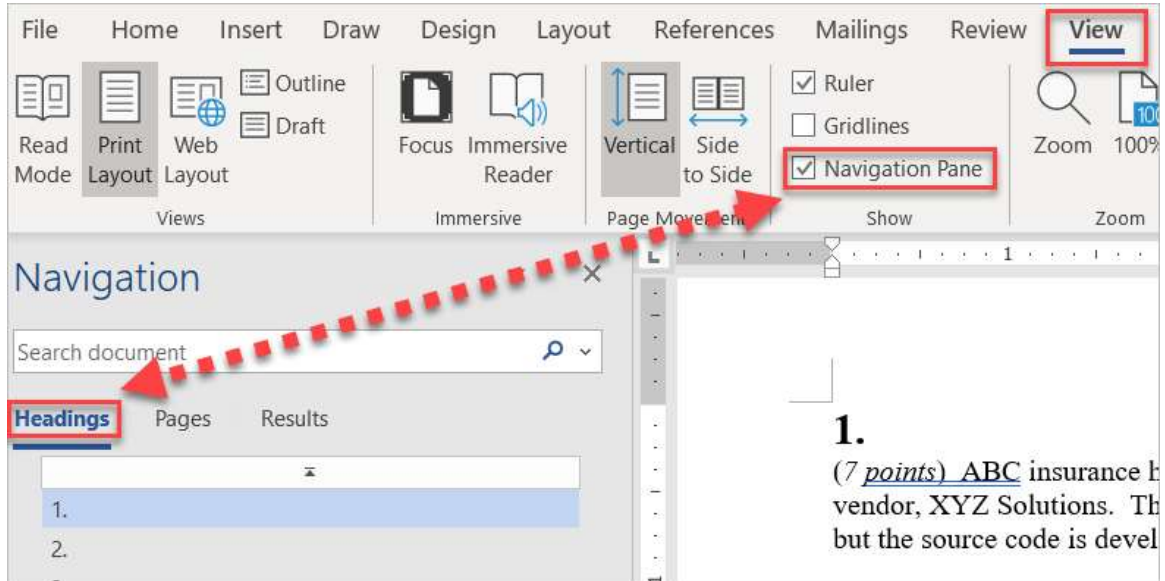
### Written-Answer Instructions

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,  $\beta_1$  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.

## Navigation Instructions

Open the Navigation Pane to jump to questions.

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



# 1.

(6 points) You are the head Actuary of the Financial Risk department at ABC Insurance. ABC Insurance provides life insurance, annuities and retirement income products. Recently, the board of directors expressed a concern that the investment portfolio backing the liabilities is heavily concentrated on Corporate Bonds and Treasury Securities. They have suggested that ABC consider exploring other fixed income investments. You have been asked to explore the mortgage market and assess the potential of adding Residential Mortgage-Backed Securities (RMBS) to the portfolio.

You are given the following regarding a single mortgage within an RMBS:

Value of the property	\$350,000.00
Loan amount requested	\$291,000.00
Monthly mortgage payment	\$1,389.28
Monthly PMI payment	\$167.00
Monthly property tax	\$110.00
Monthly HOA dues	\$50.00
Borrower's pre-tax monthly income	\$5,600.00
Borrower's other monthly debt payments (auto loans and credit card debt)	\$400.00

(a) (2 points) Calculate the following:

- Loan-to-Value Ratio of this mortgage.
- Front-end Debt-to-Income Ratio of this mortgage
- Back-end Debt-to-Income Ratio of this mortgage.

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

## 1. Continued

The Chief Investment Officer is concerned about the influence mortgage prepayments can have on the return characteristics of an Agency RMBS and has you to perform some analysis. The actuarial intern in your department has started completing a cash flow schedule shown in Excel:

Face Amount	\$1,000,000
Term (months)	360
Net Weighted Average Coupon (annual)	4%
Monthly Payment	\$4,774.16

(b) (3 points)

- (i) (2 points) Calculate the Prepaid Principal in each period in the cashflow projection using a 0 PSA model and a 150 PSA model.

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

- (ii) (1 point) Calculate the Weighted Average Life under each PSA model.

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

The actuarial intern in the financial risk department has done some work to determine the annualized cash flow yield and has discovered that there is an immaterial difference in annualized yield under the two PSA model above (0 PSA and 150 PSA).

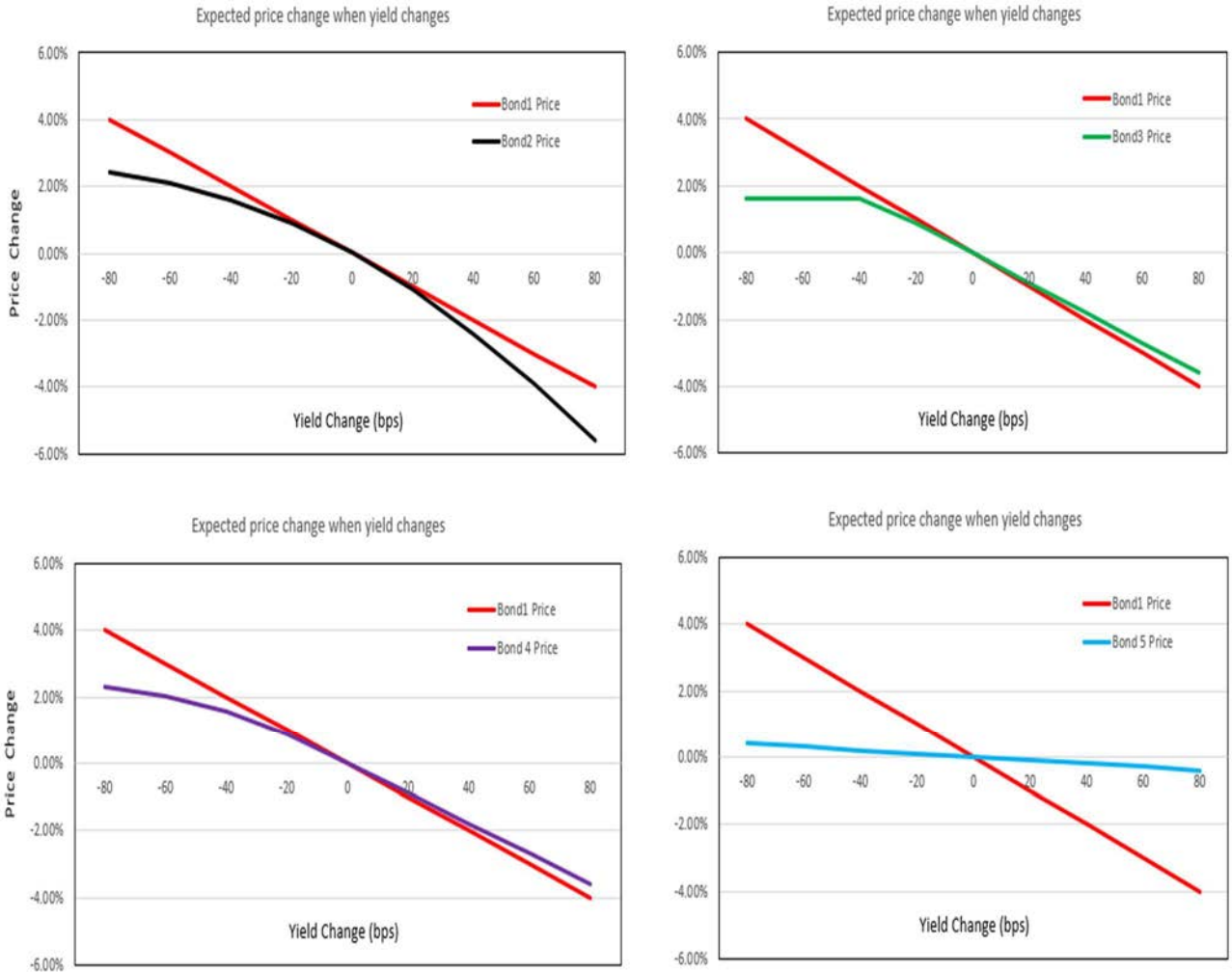
The intern stated, “Since the annualized yield is the same in the two PSA models, the different PSA model assumptions don’t actually have much of an impact on the potential returns of the Agency RMBS.”

- (c) (1 point) Critique the intern’s statement.

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

## 2.

(6 points) The expected price behavior of five coupon bonds is shown in the graphs below, labeled Bond1 through Bond5, respectively. Each of Bonds 2 through 5 is shown below compared against Bond 1. The remaining maturity of each bond is 10 years.



- (a) (3 points) Explain the key feature (or features) that leads to the price behavior of each of the five bonds.

ANSWER:

## 2. Continued

Your firm owns 1,000 XYZ bonds, each bond has a par value of \$1,000.

On November 11, 2024:

- The market price of XYZ bonds that your firm owned = \$1,024.06 per \$1,000 par value.
- A broker borrowed 700 XYZ bonds from your firm with 100% cash collateral to support the value borrowed.
- Your firm decided to use 100% of the cash collateral to buy ABC bonds on November 11, 2024.
- Total payment for the bond purchase (including accrued interest) on settlement date is to be covered by the cash collateral.

Additional information on the ABC bond:

- The par value of each bond = \$1,000.
- Bond price (excluding the accrued interest) on the trade date of November 11, 2024 = \$995 per \$1,000 par value.
- The settlement date is November 14, 2024.
- The coupon payment date is each March 15 and September 15, respectively.
- Total accrued interest (based on 30/360 convention) that your firm paid for ABC bond on the settlement date = \$3,034.

- (b) (2 points) Calculate the number of ABC bonds your firm purchased and the coupon rate of the ABC bond.

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

100% of your firm's current investment assets are publicly-traded fixed-income securities. You are asked to propose other assets that can help the firm to hedge against the inflation risk.

- (c) (1 point) Describe the types of assets that you would propose.

ANSWER:

### 3.

(5 points)

- (a) (1.5 points) Describe the three broad approaches to asset allocation.

ANSWER:

You work as an investment actuary for JKL Company, which has a defined benefit plan where benefits grow with inflation. Currently, the defined benefit plan is exactly 100% funded. Your colleague suggests that the asset allocation for the pension plan should be 100% in fixed income, given that the plan is fully funded.

- (b) (1.5 points) Evaluate your colleague's recommendation.

ANSWER:

JKL Company has a fund set aside for charitable contributions. Key information about the fund is as follows:

- The current fund balance is \$20 million
- The fund is planning to make a \$1 million contribution to a charitable organization in 12 months
- The fund has a risk aversion coefficient ( $\lambda$ ) of 2
- The fund has a goal of maintaining a fund value equal to the current fund balance plus growth for 12 months of inflation.
- Expected inflation for the next 12 months is 2%
- You have determined his utility function to be  $U_m = E(R_m) - 0.005\lambda\sigma_m^2$ .

The following asset allocation options are available to the fund.

Asset Allocation	Expected Return (%) $E(R_m)$	Standard Deviation of Return (%) $\sigma_m$
A	12	20
B	9	10
C	7.25	5

- (c) (2 points) Recommend the best asset allocation option for the fund.

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

#### 4.

(4 points) You work as an investment advisor for the board of directors of a major pension plan and the board is asking for your expertise on some changes that they're looking to implement. One of the major changes being considered involves switching the \$120B equity portfolio's investment strategy from an active strategy to a passive strategy. This change is being considered because some of the board members believe that the investment expenses paid to portfolio managers (PMs) to actively manage the equity portfolio don't justify the few instances that the portfolio outperforms its benchmarks.

The board is concerned with potential tracking errors that may arise from a passive strategy and wants to better understand the causes of those errors.

- (a) (1 point) Describe three potential causes of tracking errors for a passive strategy.

ANSWER:

- (b) (2 points) Explain three reasons why it is not appropriate for the pension plan to change its equity strategy from an active strategy to a passive strategy based on their above rationale.

ANSWER:

The board decided to examine some of the drivers of the active strategy's underperformance, and they noticed that the bulk of the underperformance is due to operations; namely, the active strategy isn't being administered in an efficient manner. The following are the key operational issues that were found:

- PMs would often leave plan member deposits in a cash account until they find the best opportunity for investment
- PMs would often have trouble capitalizing on short-term opportunities in the market

- (c) (1 point) Describe how you can use equity futures to address the above operational issues.

ANSWER:

## 5.

(8 points) You are a senior associate for XYZ Fund, a U.S. fund management firm located in Europe. You are enlisted to assist with managing its two investment portfolios.

Portfolio 1 supports XYZ's DB pension plan with the majority of the assets invested in the fixed-income market. The DB pension plan liabilities include a mixture of CPI-indexed and level payouts. Due to a recent unexpected change in government legislation, a large number of plan participants are now expected to retire over the near term.

- (a) (1 point) Describe the type of fixed-income mandate that XYZ's pension plan is most likely to adopt.

ANSWER:

The firm came up with four fixed-income strategies, that is, investing in Bonds A, B, C or D below:

	Bond A	Bond B	Bond C	Bond D
Issuer Type	Government	Corporate	Corporate	Government
Cash flow characteristics	Fixed-coupon	Floating-coupon	Fixed-coupon	Inflation-linked
Maturity (years)	12	15	3	5
Months since issuance	3	New	12	6
Outstanding issuance (\$ millions)	7,000	2,500	4,000	5,500

- (b) (1.5 points) Recommend which bond to invest for XYZ's DB pension plan.

ANSWER:

Portfolio 2 is a global bond portfolio. It adopts a total return mandate with enhanced indexing approach via stratified sampling.

- (c) (1.5 points) Describe stratified sampling and its steps.

ANSWER:

## 5. Continued

The long-term return objective is to achieve an absolute expected return of 3%. Selected financial data are presented below:

Select portfolio composition data	<ul style="list-style-type: none"><li>• 35% Convertible bond</li><li>• 35% Puttable and Callable bonds</li></ul>
Portfolio value (euro millions)	289
Average bond coupon payment (per 100 par value)	3.57 euro
Coupon frequency	Annual
Current average bond price	99.27 euro
Expected average bond price in one year (assuming an unchanged yield curve)	98.43 euro
Average bond modified convexity	16
Average bond modified duration	3.88
Average bond effective convexity	19
Average bond effective duration	4.12
Expected average yield and yield spread change	0.18%
Expected credit gains	0.13%
Expected change due to appreciation of euro	0.65%

(d) (2.5 points) Assess whether the return objective is satisfied.

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

One year later, the return of the global bond portfolio is 2.9%. To enhance return, you consider applying leverage methods.

(e) (1.5 points) Describe three methods of leveraging fixed-income portfolios.

ANSWER:

## 6.

(5 points)

- (a) (1 point) Describe the three approaches to performance attribution.

ANSWER:

You work as an investment analyst for XYZ Company and have been tasked with providing return attribution results for their equity portfolio. The table below provides the relevant information on XYZ's portfolio and the benchmark portfolio.

	<b>XYZ Weight</b>	<b>Benchmark Weight</b>	<b>XYZ Return</b>	<b>Benchmark Return</b>
Financials	40%	40%	15%	10%
Technology	20%	30%	-5%	-1%
Energy	40%	30%	3%	0%

- (b) (2.5 points) Calculate each of the following for XYZ's portfolio using the Brinson-Fachler model.

- Excess Return
- Allocation Effect
- Selection Effect
- Interaction Effect

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

XYZ is now reviewing its fixed income portfolio allocations. Your colleague suggests that the company should establish an overweight allocation relative to the benchmark portfolio for long-term corporate bonds given the company's expectation that the risk-free interest rate curve will shift from upward sloping to inverted.

- (c) (1.5 points) Evaluate your colleague's recommendation assuming the company's expectation for the risk-free interest rate curve will materialize as expected.

ANSWER:

## 7.

(4 points) You are a credit risk analyst at XYZ Bank, responsible for assessing individual loan exposures and managing the bank's overall credit portfolio risk.

An analyst on your team, Jean, has made the following comments about the Level 2 (Intermediate) Credit Portfolio Management (CPM) as defined in The Handbook of Credit Risk Management:

- I. Stress testing is done to evaluate how the portfolio will behave in circumstances reflecting historical extremes.
- II. When rebalancing transactions, only transactions incurring losses will be replaced.

(a) (1 point) Critique each of Jean's comments.

ANSWER:

XYZ Bank issued a \$50 million term loan to a manufacturing company ABC to fund its expansion. The company has provided a facility valued at \$20 million as collateral for the loan. The bank's internal credit models assume:

- I. Probability of Default: 3%
- II. Recovery rate: 40%

(b) (1 point) Calculate the expected loss of this loan using the net exposure.

ANSWER:

Your manager warns that you should be careful about the true value of collateral.

(c) (1 point) Describe three checklist items that should be considered when evaluating collateral value.

ANSWER:

## 7. Continued

The majority of XYZ's loans are made to ABC. Your manager believes that XYZ's credit risk exposure to the manufacturing sector is too high.

- (d) *(1 point)* Describe two Level 3 CPM techniques XYZ can use to manage its credit risk exposure.

ANSWER:
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## 8.

(5 points) You work for a company that currently has 2 portfolios of equal asset size.

Portfolio 1 is well diversified with 10,000 obligors and each obligor has the same exposure.

Portfolio 2 is targeted and has 100 obligors of varying exposures.

The expected default rate of all obligators is 1% and assumed to be independent.

All defaults are assumed to default in entirety, thus the expected default of both portfolios is equal.

Two approaches are being considered for determining the distribution of default losses: Numerical approach and Analytical approach.

(a) (2 points) Recommend which approach would best suit each portfolio.

ANSWER:
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You have decided that independent defaults is a poor assumption and would like to incorporate correlation of defaults ( for example 0.05) while keeping the same expected default rate. Assume you will use a dependent beta-binomial mixture model in order to model the default distribution, calibrated to the average default rate and default correlation. Assume in part (a) you used an independent default binomial model to model the default distribution.

(b) (1 point) Describe the expected impact to the default loss distribution assuming correlation of defaults.

ANSWER:
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## 8. Continued

You would now like to explore a portfolio with different default rates. You would like to use the one factor CreditRisk+ model. You will force the parameters,  $\omega_0$  and  $\omega_1$ , to sum to 1 and you will select the gamma-distributional parameters,  $a$  and  $b$ , such that  $E(S) = 1$ .

- (c) (1 point) Describe the problem you will encounter in calibrating the model assuming a portfolio wide unconditional default probability of 0.01 and an average default correlation of 0.05. (Note: no formulas are required to answer this question)

ANSWER:

You would now like to account for additional systematic factors present among the portfolio which include industry, region and company size. You plan to expand to a multi-factor CreditRisk+ model.

- (d) (1 point) Describe the additional assumptions that will be required to calibrate the model assuming a portfolio wide unconditional default probability of 0.01 and an average default correlation of 0.05. (Note: no formulas are required to answer this question)

ANSWER:

## 9.

(7 points) JJ is an analyst in a life insurance company, whose team manages the fixed income portfolio for the whole life product segment. JJ's team uses various fixed-income instruments and derivatives in the portfolio.

A mortgage-backed security (MBS) in the portfolio has a face value of 500,000, with a 5% fixed coupon rate and 30-year term.

The market price is \$480,000.

In JJ's analysis, when the interest rates are shocked by 0.5%, the MBS market value will change to \$455,000 for +0.5% or \$490,000 for -0.5%.

(a) (2 points)

(i) (1 point) Calculate the duration of the MBS security.

ANSWER:

(ii) (1 point) Explain why the magnitude of the change in market value when interest rates increase is higher than when interest rates decrease.

ANSWER:

The fixed income portfolio also has Treasury STRIPS and MBS Interest-Only (IO) and Principal-Only (PO) securities.

(b) (2 points)

(i) (1 point) Explain how the market value of MBS IO and MBS PO securities would change when interest rates go up.

ANSWER:

(ii) (1 point) Explain why Treasury STRIPS are preferred over MBS IO/PO securities in a fixed-income portfolio that supports pension-type liabilities that are entirely made up of retirees.

ANSWER:

## 9. Continued

JJ's team is looking to assess the credit risks associated with the corporate bond portfolio. JJ suggests modeling the credit losses using a Poisson-Gamma Model. The average default probability of the corporate bonds is 0.5%, with a variance of 0.000995.

(c) (2 points)

- (i) (1 point) Calculate the alpha and beta parameters of the Poisson-Gamma model.

ANSWER:

- (ii) (1 point) Explain why calibrating a Poisson-Gamma Mixture model requires less runtime than calibrating a Probit- and Logit Normal Mixture model.

ANSWER:

The portfolio has corporate bonds from issuers from various industries and continents; for example, the portfolio has corporate bonds issued by Australian banks and corporate bonds issued by American food processing companies.

- (d) (1 point) Explain the limitation of the Gaussian model for credit risk in modeling this portfolio.

ANSWER:

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