Exam CP 312

Date: Thursday, November 20, 2025

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 6 questions numbered 1 through 6 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, 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 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 time expires.

Navigation Instructions

Open the Navigation Pane to jump to questions.

Press Ctrl+F, or click View > Navigation Pane:
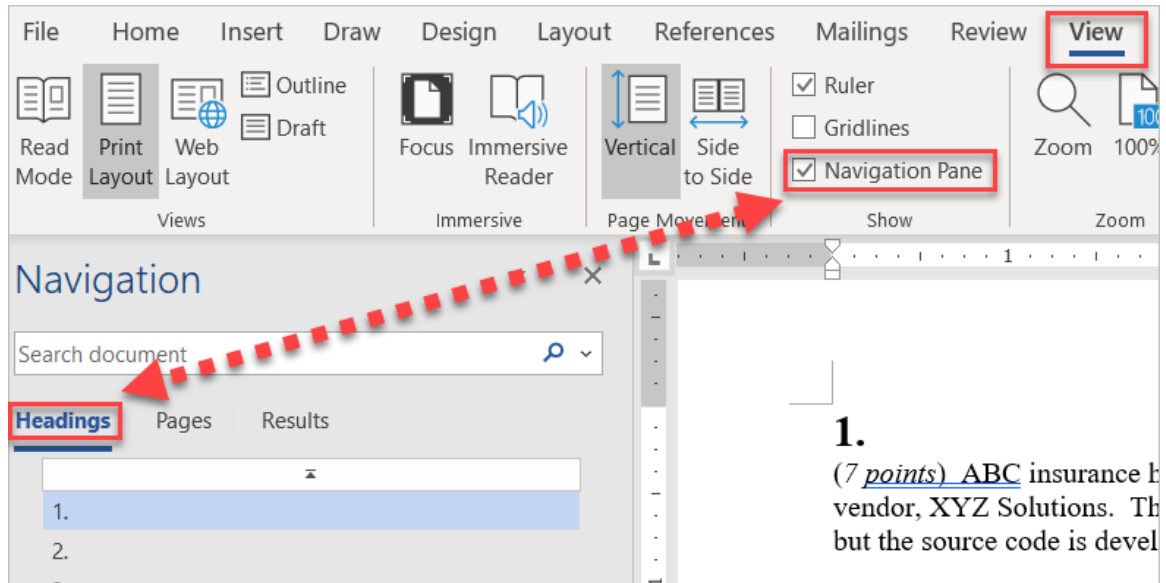
1.

(*10 points*) You work on a valuation team for GEG Life, a major Fixed Annuity company who is looking to enter the Fixed Indexed Annuity (FIA) space.

Their current product portfolio consists of multi-year guaranteed annuities (MYGAs).

The pricing team has built a model to price these new products by modifying their existing MYGA model. The proposed FIA design is currently without a cap. The model was set up with the assumption to hold the risk-free rate constant throughout the projection and to use the time-zero implied volatility throughout the projection.

Management has instructed your team to use the original model created by pricing to produce a projection model for the new FIA block.

(a)   (*1 point*) Describe two differences in modeling FIAs and MYGAs.

ANSWER:

(b)   (*1 point*) Recommend a possible modeling improvement to each of the following:

(i)   (*0.5 points*) The implied volatility rate assumption

ANSWER:

(ii)   (*0.5 points*) The risk-free rate assumption

ANSWER:

The improvements proposed in part (b) had an impact on runtime. The runs were performed with the following characteristics:

Number of Model Points	894,000
Number of Inner Loop Scenarios	5,000
Number of Outer Loop Scenarios	5,000
Projection Period	30 years
Inner Loop Calculation Points	Quarterly
Model Output	Present Value of Net Income

1.   Continued

(c)   (*2 points*) Recommend two methods to reduce the runtime. Justify your
        recommendation.

ANSWER:

(d)   (*3 points*) Critique each of the following statements from a draft email response
        written by a coworker to management:

A.   *Since the pricing model has been validated by the pricing team there is no
       further need for validation.*

ANSWER:

B.   *The assumptions used by pricing should be reviewed for appropriateness
       in a reserving calculation.*

ANSWER:

C.   *We have added the necessary functionality to model current and future
       assets, with all the assumptions provided by our investment team.*

ANSWER:

D.   *The pricing team is considered experts regarding this product, and we rely
       on their expertise; this reliance will be documented in our model
       documentation.*

ANSWER:

1. **Continued**

> E. *Since the pricing model for this product is included in the model inventory list, it is not necessary to add a new entry for the version used to calculate the reserve.*

ANSWER:

(e) (*3 points*) Management is provided a report with the following information (in millions):

Run Description	VaR(90)	CTE(80)
Base Run	-14.7	-16.0
Lapse up 10%	-15.5	-29.0
Interest Rates up 100bps	-15.0	-22.4

(i) (*2 points*) Recommend a product feature that will help address the risks implied by the results.

ANSWER:

(ii) (*1 point*) Evaluate the quality of the report in the context of model validation. Justify your response.

ANSWER:

2.

(*10 points*) DFW Life is adding additional non-traditional crediting strategies to their fixed indexed annuities (FIAs). These new strategies are based on a volatility control index targeting 6% volatility with annual crediting based on a monthly point-to-point with cap calculation.

You've been asked to consult on the design of the model for this product.

(a) (*1 point*) Evaluate whether Black-Scholes should be used to model the crediting strategy for this product.

> ANSWER:

(b) (*3 points*) Assess the appropriateness of the following steps to calibrate and test a machine learning proxy model using Monte Carlo valuation of this product.

   (i) (*0.5 points*) Overview and problem statement: Perform the valuation of the non-traditional option using deterministic equity paths and stochastic interest rates.

   > ANSWER:

   (ii) (*0.5 points*) Preparation: Decide which software to use to build the model.

   > ANSWER:

   (iii) (*0.5 points*) Data Generation: Randomize the features or input fields driving change in the market value of the options. Target 1,500 - 3,000 observations with 50% of them being reset and 50% being in between annual resets.

   > ANSWER:

   (iv) (*0.5 points*) Feature Engineering and Selection: Not needed because enough data was generated in an earlier step. This step is only needed to reduce runtime.

   > ANSWER:

2. Continued

    (v)   (*0.5 points*) Model Testing and Selection: Select and test various machine learning models. Calculate R2 and a mean absolute error for each model tested to assess the fit.

> ANSWER:

    (vi)   (*0.5 points*) Actuarial Evaluation: Compare results from the machine learning model to the results by the actuarial model, assessing the fit of the model against industry benchmarks.

> ANSWER:

(c)   (*2 points*) Recommend two features to include in the proxy model to provide greater predictive power. Justify your recommendations.

> ANSWER:

(d)   (*2 points*) Recommend two validation techniques to gain assurance that the results from the proxy model are appropriate for this use case. Justify your recommendations.

> ANSWER:

(e)   (*2 points*) DFW Life's ERM team is concerned about the regulatory environment regarding AI and bias.

    (i)   (*1 point*) Assess the Monte Carlo proxy model developed in part (b) for bias and fairness. Justify your response.

> ANSWER:

    (ii)   (*1 point*) Contrast the AI regulatory environment between the United States and other countries.

> ANSWER:

3.

(*9 points*)

(a) (*2 points*) Hull-White (HW) 1-factor model and Libor Market Model (LMM) are models used to stochastically project future interest rate scenarios.

Identify the following features for each of the two models:

(i) (*0.5 points*) Type of model (i.e., short rate or term structure)

ANSWER:

(ii) (*0.5 points*) Ability to reflect mean reversion of interest rates

ANSWER:

(iii) (*0.5 points*) Possibility of forecasting negative interest rates

ANSWER:

(iv) (*0.5 points*) Other notable strengths of each model

ANSWER:

(b) (*2 points*)

(i) (*1 point*) Describe the general method for calibration and validation of interest rate models

ANSWER:

(ii) (*1 point*) Assess the applicability of the method to the HW and LMM models

ANSWER:

3.   Continued

(c)   (*3 points*) A fixed indexed annuity (FIA) profitability model measures present value of net income at CTE(70) for a large in-force block, using 1,000 projected economic scenarios. The model owner is investigating methods to reduce runtime.

(i)   (*1 point*) Describe the scenario ranking method.

ANSWER:

(ii)   (*1 point*) Outline the steps to improve the accuracy of scenario ranking method.

ANSWER:

(iii)   (*1 point*) Describe the cluster modeling method.

ANSWER:

(d)   (*2 points*) The FIA profitability model is an Excel model that is not part of a production environment.

Propose a process control plan for this model.

ANSWER:

4.

(*10 points*) EWR Life is in the process of building a proxy model to project stochastic net income for fixed index annuity (FIA). The proxy model will be used for quarterly capital reporting which includes the CTE(95) of the results.

(a)   (*2 points*) Describe three aspects of a proxy model that need to be evaluated before using it for this purpose.

> ANSWER:

(b)   (*8 points*) You are given the following information:

- **The FIA product features are:**
  - S&P 500 Movement
  - Annual point-to-point
  - A minimum credit of 0%
  - A cap of 7%
  - A participation rate of 100%

- **The index values are:**
  - End of policy year 1 is 105
  - End of policy year 2 is 100

You are looking at two stochastic processes to replace the current equity scenario generator, both with annual time steps:

- **Independent lognormal (ILN)**

$\frac{S_t}{S_0} \sim \log N\,(t\mu, \sqrt{t}\sigma)$, where

| $\mu = 0.07$ |
| $\sigma = 0.08$ |

4. **Continued**

- **Generalized auto-regressive conditionally heteroscedastic (GARCH)**

$$\frac{S_t}{S_0} = \exp{(Y_1 + Y_2 + \cdots + Y_t)}$$

$$Y_t = \mu + \sigma_t \varepsilon_t \text{ where } \varepsilon_t \sim N(0, 1)$$

$$\sigma_t^2 = a_0 + a_1(Y_{t-1} - \mu)^2 + b\sigma_{t-1}^2, \text{ where}$$

$\mu =$	0.07
$\sigma^2 =$	0.0064
$a_0 =$	9.5×10^{-5}
$a_1 =$	0.8
$b =$	0.51

Calculate the probability for each of the following events occurring for each of the stochastic processes at the end of policy year 3:

(i) (*3 points*) There is no index benefit paid.

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

(ii) (*3 points*) An index benefit of 7% is paid.

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

You are provided output from the current scenario generator for 1000 scenarios in the Excel workbook, tab "Q4_Returns".

(iii) (*2 points*) Compare the results from parts (i) and (ii) with the provided returns.

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

5.

(*8 points*) You are the lead modeling actuary for YYZ Life. The company is preparing to enter the fixed deferred annuity market and has asked your team to develop a pricing model for a multi-year guaranteed annuity (MYGA) product with a 10% free withdrawal feature.

(a)   (*3 points*) Evaluate the impact of each of the following simplifications on model accuracy, reliability, and efficiency:

(i)   (*1.5 points*) Reserves are set equal to account value.

ANSWER:

(ii)   (*1.5 points*) Policyholder behavior modeled using a static lapse assumption.

ANSWER:

(b)   (*2 points*) Critique each of the following statements for a MYGA pricing model:

A.   *An annual time-step will greatly reduce model runtime with minimal loss of accuracy.*

ANSWER:

B.   *An effective way to model a portfolio crediting rate strategy is to use the updated asset portfolio rate at the end of the current time-step as the crediting rate for the next time-step.*

ANSWER:

C.   *If a proxy model is being used for asset portfolio yields, the projected portfolio rate should be adjusted downward whenever there is negative cash flow.*

ANSWER:

5. Continued

      D.   Lapses can be adequately projected using a static lapse assumption.

> ANSWER:

(c)   (*2 points*) YYZ plans to invest MYGA funds in government bonds, corporate bonds, mortgages, and asset-backed securities.

    Evaluate the advantages and disadvantages of using a proxy model for asset portfolio yields that allocates a fixed percentage of investable cash flow to 5-year, 10-year, and 20-year corporate bonds, assuming a single Portfolio Spread.

> ANSWER:

(d)   (*1 point*) You are thinking about using a third-party model to price YYZ's MYGA product. You have limited access to the source code and assumptions but have been provided with high-level documentation and output reports.

    Describe two considerations about this model before relying on it based on guidance from ASOP 56.

> ANSWER:

6.

(*3 points*) BDA Life offers the following products:

- A variable universal life (VUL) with a secondary guarantee
- A universal life with a secondary guarantee (ULSG)
- A variable annuity (VA) with a guaranteed minimum death benefit

You are given:

- The ULSG model uses stochastic interest rates.
- The VUL product offers only equity funds.
- The VA model proxies the separate account returns based on the S&P 500 and a fixed income index. There is performance data for both indices starting in 1945.

(a) (*1 point*) You are tasked with creating a new pricing model for the VUL product. Your manager proposes to start with the current ULSG pricing model and only update the interest rate scenarios, since these products have the same risks.

Evaluate your manager's proposal.

ANSWER:

(b) (*1 point*) Propose a way to benchmark performance between the VA model and the new VUL model.

ANSWER:

(c) (*1 point*) Recommend the depth of a validation report for the VUL model.

ANSWER:

END OF EXAMINATION