

# Exam CP 312

Date: Friday, March 27, 2026

## INSTRUCTIONS TO CANDIDATES

### General Instructions

1. This examination has 5 questions numbered 1 through 5 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.

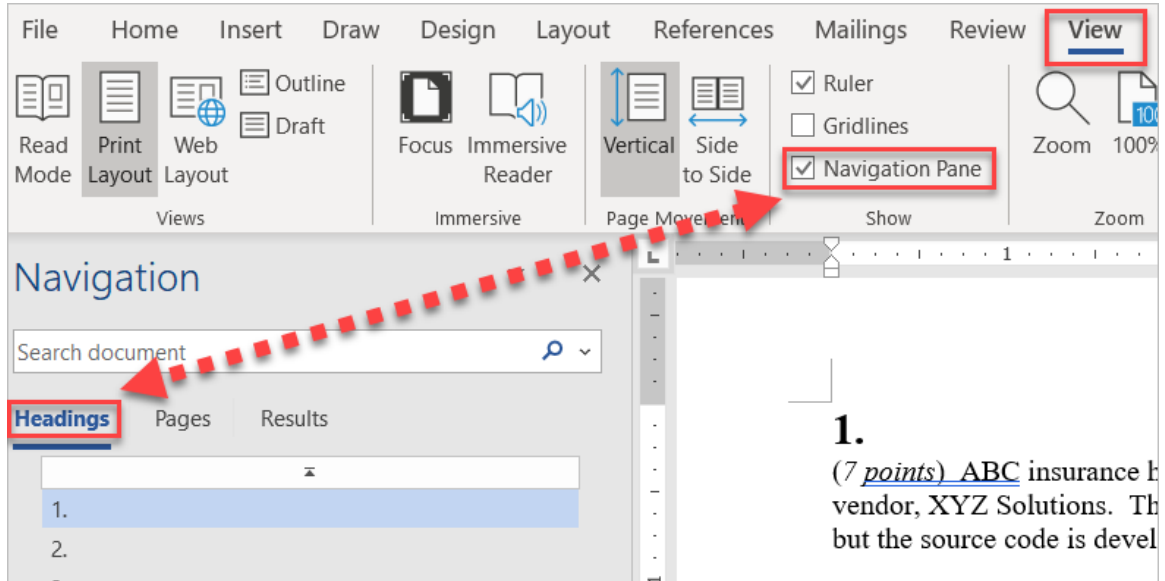
### Written-Answer Instructions

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 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.

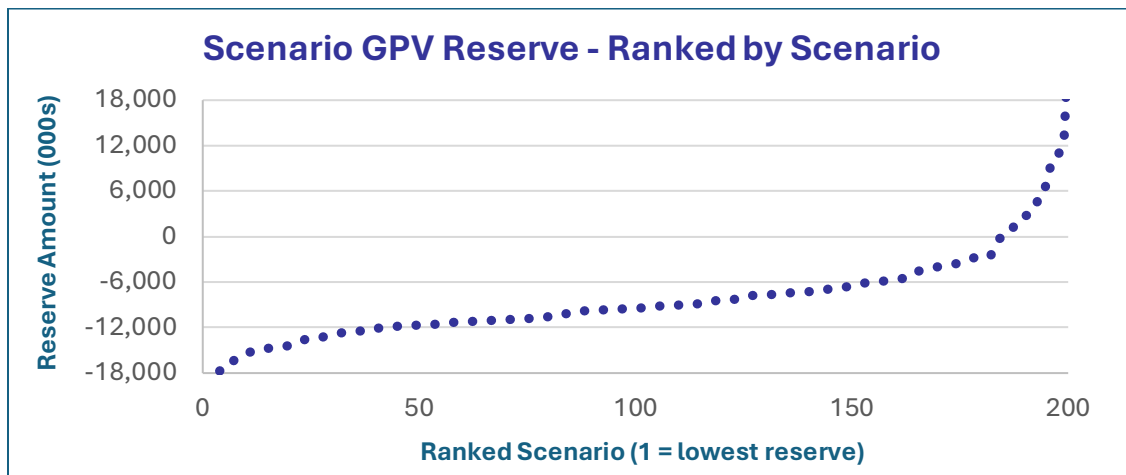
(12 points) You are calibrating an Economic Scenario Generator (ESG) to evaluate pricing adequacy and capital requirement for a block of Universal Life with Secondary Guarantee (ULSG) policies. This block is highly sensitive to interest rates, as the long-duration secondary guarantees create significant tail risk under adverse scenarios.

The gross premium valuation (GPV) reserve distribution results from the ESG output using 200 scenarios are shown below. Use this result to answer the following questions.

## Risk Measures

### GPV Reserve

Average	(8,386)
Std Dev	5,822
70%-tile	(7,205)
CTE-70	(1,928)
CTE-98	14,639



## 1. Continued

(a) (4 points)

- (i) (2 points) Interpret results in the context of ULSG based on the GPV reserve distribution summaries using the summary statistics table and the Scenario GPV Reserve graph.

ANSWER:

- (ii) (2 points) Evaluate the most effective and least effective calibration procedure to capture the low-interest rate persistence and tail risk.

ANSWER:

(b) (4 points)

- (i) (1 point) List two advantages and two disadvantages of a one-factor Hull-White model in projecting interest rates for this ULSG block.

ANSWER:

- (ii) (3 points) Recommend modeling practices that help maintain consistency across economic scenarios when projecting dynamic models of secondary guarantees within a ULSG block. Justify your answer.

ANSWER:

(c) (2 points) With respect to stress testing of a ULSG product:

- (i) (1 point) Evaluate the suitability of using the Academy Interest Rate Generator (AIRG).

ANSWER:

- (ii) (1 point) Recommend the components to be included in the calibration of the model. Justify your answer.

ANSWER:

## 1. Continued

(d) (2 points)

- (i) (1 point) Construct a governance framework that ensures ongoing appropriateness and oversight of key modeling assumptions for the ULSG block.

ANSWER:

- (ii) (1 point) Propose a model change control process for this ULSG block as the Experience Studies team is proposing implementing a new lapse assumption next year. Justify your answer.

ANSWER:

## 2.

(9 points) Your company sells a variable annuity product with the following characteristics:

- A guaranteed minimum death benefit (GMDB)
- A guaranteed minimum accumulation benefit (GMAB)
- A large number of investment options, including fixed income, ETFs, and managed funds

The product has been on the market for many years and is generally successful, with approximately 500,000 policies in force.

The chief actuary is interested in improving the valuation modeling of this product and has come to you for some information.

- (a) (3 points) The chief actuary is interested in adding a dynamic lapse assumption to the model.

Assess the suitability of using dynamic lapse assumption for this variable annuity product, based on how each of the three given characteristics may impact the dynamic lapse assumption.

ANSWER:

- (b) (4 points) The chief actuary is considering using a set of 10,000 economic scenarios as part of the valuation model but is concerned about the amount of time needed to calculate the reserves. You have been presented with several different approaches to increase computational efficiency on this block of business.

Evaluate the appropriateness of each approach specified below:

- (i) (1 point) Scenario Reduction

ANSWER:

- (ii) (1 point) Inforce Compression

ANSWER:

## 2. Continued

(iii) (1 point) Increase computing power (more computers)

ANSWER:

(iv) (1 point) Simplify the valuation model

ANSWER:

(c) (2 points) Several tasks are required for model governance during the new model's implementation:

- Peer review the quarterly reserve calculation that is reported on the company's financial statements
- Calculate the regulatory capital requirements of the company
- Prepare responses to audit challenges
- Develop the policy for frequency of performing experience studies and updating mortality and lapse assumptions
- Reconcile the inforce data used in the valuation model to the administrative system.

Identify the line of defense each of the above task falls under using the “three lines of defense” model risk management framework.

ANSWER:

### 3.

(9 points) You are a modeling actuary at BOS Life Insurance Company, responsible for the proxy model of a universal life with secondary guarantees (ULSG) product.

- (a) (1 point) Contrast the  $t=0$  projections methodology and the outer-inner loop nested projections methodology.

ANSWER:

- (b) (3 points) Critique the following statements:

A. *Proxy models are distinctive from other models because they approximate reality.*

ANSWER:

B. *The proxy model with the most accurate output should be selected.*

ANSWER:

C. *Proxy models help solve the problem of modeling demand overtaking computational power.*

ANSWER:

D. *Modeling no excess lapses on ULSG is a reasonable assumption.*

ANSWER:

E. *Modeling higher long-term lapse rates on ULSG once the AV reaches 0 would decrease projected earnings.*

ANSWER:

### 3. Continued

- F. *Low interest rate scenarios lengthen the amount of time for the secondary guarantee to become in-the-money.*

ANSWER:

You are given projection output from the ULSG proxy model for both a  $t=0$  projection and an inner-loop from an outer-inner loop projection.

(c) (3 points)

- (i) (1 point) Calculate the  $t=0$  projection's gross premium reserve on December 31, 2028.

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

- (ii) (1 point) Calculate the inner-loop projection's gross premium reserve on December 31, 2028.

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

- (iii) (1 point) Explain the impact on the projected profit margin if BOS Life were to use the  $t=0$  values for this product rather than the inner-loop values.

ANSWER:

You recently re-calibrated the ULSG proxy model and are looking to validate the model output.

- (d) (2 points) Describe four considerations for validating ULSG proxy model output based on guidance from *ASOP 56, Modeling*.

ANSWER:

#### 4.

(10 points) You are an actuary working on projecting the fair value of variable annuity guarantees for pricing. You use a nested stochastic Monte Carlo simulation with 1000 real-world outer loops and 1000 risk-neutral inner loops at 50 annual time steps. There has been a lot of scrutiny around the excessive runtimes each quarter of your model.

(a) (2 points)

(i) (1 point) Explain the reasons for using a nested stochastic model in this case.

ANSWER:

(ii) (1 point) Describe the calibration process of market-consistent ESG models and parametrization of real-world ESG models.

ANSWER:

(b) (3 points) Critique the following proposals to improve the model's runtime.

(i) Implement scenario ranking by running the first 5% of the policies through the full model, ordering the results and then running the rest of the policies through the worst 300 scenarios.

ANSWER:

(ii) Implement importance sampling without running the full 1000 scenarios by ordering the scenarios based on the year 2 equity rate, choosing 100 from the first third, 100 from the second third and 100 from the last third, and taking the mean of those results.

ANSWER:

## 4. Continued

- (iii) Implement random sampling by running policies through the same 300 random scenarios to approximate the results for the 1000 scenarios.

ANSWER:

- (c) (2 points) The number of inner loop scenarios has been reduced from 1000 to 250. However, this scenario reduction led to significant variation in fair value calculations from period to period, even with minor underlying market assumption changes.

Propose a variance-reduction method that uses a correlated, analytically tractable variable to stabilize results without increasing the number of simulations. Justify your answer.

ANSWER:

- (d) (3 points) In the previous quarter, the counterparty on an interest rate swap used to hedge the fair value GLWB liability defaulted. This highlighted a limitation of the model, as the counterparty risk has not historically been factored in the projection. You are given the following average risk-neutral projection results for default exposure on a block of hedges with a single counterparty:

Trade	Notional Amount	Year 0	1	2	3	4	5
A	1,000,000	0.89%	-1.26%	0.47%	-0.51%	0.76%	0.23%
B	1,000,000	-0.44%	0.44%	-1.06%	1.82%	-1.51%	0.00%
C	1,000,000	-0.85%	-0.30%	-0.89%	1.14%	-0.98%	1.90%
D	1,000,000	0.88%	0.73%	0.25%	0.42%	0.84%	-0.79%
E	1,000,000	-1.80%	0.47%	-0.73%	-1.38%	1.49%	1.13%

- (i) (1 point) Calculate the annual exposure to this counterparty with netting.

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

- (ii) (2 points) Calculate the net reduction in market value to the counterparty due to default losses, assuming:

- $i = 0.07$
- the expected loss rate is 25bp in all years

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

## 5.

(10 points) ABC Life plans to significantly expand its Individual Disability Insurance (IDI) business by improving pricing accuracy, risk assessment, and reserving methodologies. To support this growth, ABC is making the following changes to its IDI models:

- Transition from a legacy claim cost model to a multi-state first-principles model
- Integration of economic scenario analysis into claims forecasting

(a) (2 points) You are asked to implement a multi-state first principles model for the IDI business.

Evaluate the advantages and disadvantages of the model.

ANSWER:

(b) (2 points) Critique the following statements regarding IDI models:

A. *It is unnecessary to model state transitions explicitly in an IDI first principles model, since the cash flows can be calculated directly from incidence and termination rates.*

ANSWER:

B. *For projection accuracy, model time step should be smaller in the early period immediately following the commencement of disability.*

ANSWER:

C. *Applying the same lapse rates to both active and disabled lives in an IDI model is acceptable for simplifying model calculations.*

ANSWER:

D. *In an IDI model, disabled lives should be grouped into monthly cohorts to properly apply duration-dependent recovery and mortality assumptions.*

ANSWER:

## 5. Continued

- (c) (4 points) ABC currently applies a single claim duration assumption for all economic environments. It recently developed an Economic Stress Indicator (ESI) based on unemployment rates, which classifies conditions into five levels. ABC's study shows that actual-to-expected claim duration ratio increases substantially under higher ESI levels.
- (i) (2 points) Propose a method to incorporate the ESI into its claim duration assumptions.

ANSWER:

- (ii) (2 points) Describe one benefit and one drawback of the proposed method in the context of disability claim forecasting.

ANSWER:

- (d) (2 points) ABC Life is considering DevOps principles to modernize its multi-state first-principles IDI model platform. Based on *The Modeling Platform* article by Bryon Robidoux (April 2020):
- (i) (1 point) Describe the microservices in the context of a multi-state first-principles IDI model.

ANSWER:

- (ii) (1 point) Explain how continuous testing can improve the reliability of the IDI model.

ANSWER:

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