CURATED PAST EXAM ITEMS
- Questions -

CP 312 – Model Development and Governance

Important Information:

- These curated past exam items are intended to allow candidates to focus on past SOA fellowship assessments. These items are organized by topic and learning objective with relevant learning outcomes, source materials, and candidate commentary identified. We have included items that are relevant in the new course structure, and where feasible we have made updates to questions to make them relevant.
- Where an item applies to multiple learning objectives, it has been placed under each applicable learning objective.
- Candidate solutions other than those presented in this material, if appropriate for the context, could receive full marks. For interpretation items, solutions presented in these documents are not necessarily the only valid solutions.
- Learning Outcome Statements and supporting syllabus materials may have changed since each exam was administered. New assessment items are developed from the current Learning Outcome Statements and syllabus materials. The inclusion in these curated past exam questions of material that is no longer current does not bring such material into scope for current assessments.
- Thus, while we have made our best effort and conducted multiple reviews, alignment with the current system or choice of classification may not be perfect. Candidates with questions or ideas for improvement may reach out to education@soa.org. We expect to make updates annually.

Course CP 312

Curated Past Exam Questions

All Learning Objectives

Learning Objective 1: Cash Flow Models for Long-Term Insurance Business

Learning Objective 2: Non-Cash Flow and Supplementary Models for Financial Business

Learning Objective 3: Model Governance

The following questions are taken from Life ALM and Modeling Exams and Foundations of CFE Exams from 2020 – 2024. They have been mapped to the learning objectives and syllabus materials for the CP 312 2025-2026 course and in some cases modified to fit the 2025-2026 curriculum.

The related solutions and Excel spreadsheets are provided in separate files. The case study that was originally used for each question is linked at the start of each question.

Table of Contents

1. Fall 2020 ILA LAM Exam (LO 3a)

Relevant Sources:

ASOP 56: Modeling, Dec 2019, pp. 1-9

CIA Educational Note: Use of Models, Jan 2017

Model Validation for Insurance Enterprise Risk and Capital Models, CAS/CIA/SOA, 2014 (excluding Appendices)

(*7 points*) ABC insurance has licensed actuarial modeling software from a third-party vendor, XYZ Solutions. The software will be stored and used on ABC's infrastructure but the source code is developed and updated periodically by XYZ.

To protect proprietary technology ABC's access will be limited to end-user functionality but the underlying calculation engine and methodology will not be available for review or modification by ABC.

(a) **(LO 3a)** (*5 points*) Critique each statement below in the context of Model Risk Management.

A. *There are five elements of model risk defined in "Model Validation for Insurance Enterprise Risk and Capital Models". With respect to the management of this actuarial software, ABC should be concerned with all five risks.*

ANSWER:

B. *To assess and manage model reporting risk, ABC plans to survey business users as to whether they consider the reports to be useful and meaningful for decision support. To avoid asymmetric user feedback, only users that are significantly affected by the model's output are included in the survey.*

ANSWER:

C. *Allowing only in-house data and assumptions is the most effective way to manage vendor risks.*

ANSWER:

1. Continued

D. An internal review group within XYZ performed a validation of the calculation engine prior to releasing the software to ABC. No further validation of the software is required by ABC.

ANSWER:

E. ABC's actuarial model validation framework is deemed satisfactory because ABC periodically reviews the quality and conceptual soundness of the model design and construction, and the methodologies used.

ANSWER:

ABC has received a user guide for the actuarial software from XYZ. The user guide has detailed instructions on how to operate the software and descriptions of the features available to the end-users. ABC plans to supplement this guide with additional documentation to help mitigate model risk and reduce model-related costs.

(b) **(LO 3a)** (*2 points*) Identify the types of model documentation ABC should develop. Justify your answer.

ANSWER:

3. Fall 2020 ILA LAM Exam (LOs 2a, 2c)

Relevant Sources:

Economic Scenario Generators: A Practical Guide, SOA, Jul 2016, Ch. 1, 2, 4.1-4.3, 5, 6, 7.1-7.3, 8

Economic Scenario Generators – three-part series, SOA:

- Part I –Motivation for Stochastic Modeling, The Modeling Platform, Nov 2019
- Part II – Understanding Economic Scenario Generators, The Modeling Platform, Aug 2020

CP312-101-25: Stochastic Modeling, Theory and Reality from an Actuarial Perspective, sections I.A, I.B-B.2, I.B.3.a, II.B-B.1.d

(*8 points*)

(a) **(LO 2a)** (*4 points*) Critique the following statements about stochastic modeling:

A. A stochastic model with a Normal distribution is a good option if it is difficult to determine the actual underlying distribution of the process being modeled.

ANSWER:

B. Stress testing is always a good alternative to stochastic modeling.

ANSWER:

C. When using an Economic Scenario Generator, real-world scenarios will produce a more realistic expected present value of cash flows than risk-neutral scenarios. This is because the real-world scenarios use a discount rate that reflects the risk associated with the cash flows.

ANSWER:

~~*D.*~~ **No Longer Relevant** ~~*Real-world scenarios cannot be used for a market-consistent valuation.*~~

~~ANSWER:~~

3. Continued

E. Risk-neutral scenarios are calibrated using observed market prices and therefore the calibration requires very little judgment.

ANSWER:

F. The difference between the risk-neutral and real-world scenario paths is smaller when valuing long-term insurance contracts than when valuing short-term contracts.

ANSWER:

3. Continued

BNT Life wants to implement stochastic modeling techniques. The Chief Actuary has stated it is most important that the models be accurate and efficient. BNT must first decide on a random number generator and are considering using either a True Random Number Generator or a Pseudo Random Number Generator.

~~(b)~~ **NO LONGER RELEVANT** ~~(*1 point*) Recommend which Random Number Generator BNT should use. Justify your answer.~~

~~ANSWER:~~

BNT's business includes Universal Life, Whole Life, and Variable Annuities with Guarantee Minimum Withdrawal Benefit Riders. It does not currently have a hedging program but is considering implementing one.

The Chief Actuary recommends that BNT use Monte Carlo modeling instead of Nested Stochastic modeling because it is more straightforward, and simulations would take less time.

(c) **(LOs 2a, 2c)** (*3 points*) Assess the Chief Actuary's recommendation. Justify your answer.

ANSWER:

4. Fall 2020 ILA LAM Exam (LOs 1a, 2a)

Relevant Sources:

Long-Term Actuarial Models Part II, Cardinal, Timothy, Cardinalis 1 LLC, 2024

- Ch. 1: Introduction to Modeling (excluding section 1.5)

Metamodeling for Variable Annuities, Valdez, Emiliano and Gan, Guojun

- Chapters 1-3, 6

Economic Scenario Generators: A Practical Guide, SOA, Jul 2016, Ch. 1, 2, 4.1-4.3, 5, 6, 7.1-7.3, 8

(*13 points*) YYG Life, a US based insurer, offers a single premium variable annuity product with a Guaranteed Minimum Accumulation Benefit (GMAB) rider. Returns track the Nikkei 225, a weighted stock-market index in Japan.

(a) **(LOs 1a, 2a)** (*2 points*) You are developing an Economic Scenario Generator (ESG) suitable for this product.

(i) Identify the key market variables required for the ESG.

(ii) Justify why these variables are important for determining the liability of this product.

ANSWER:

NO LONGER RELEVANT

~~Based on historical returns of the Nikkei 225, YYG decided to adopt a regime-switching log-normal model to project real-world equity returns.~~

~~(b) **(LOs 1a, 2a)** (*2 points*) Discuss the pros and cons of this ESG choice.~~

~~ANSWER:~~

4. Continued

You are given the following information on the product:

Premium	50,000
M&E Fee (% of fund value, charged at BoY)	1% per annum
Lapse Assumption (lapses occur at EoY)	4% per annum
Expected Nikkei 225 Index Return (years 1 – 6)	6% per annum
Expected Nikkei 225 Index Return (year 7)	X%
GMAB Rider	
Guaranteed:	100% of premium
Maturity	End of year 7
Rider Fee (% of fund value, charged at BoY)	1% per annum
Expenses (incurred at BoY)	
1st Year Acquisition expense (% of premium)	5%
Maintenance Expense per year	200 per annum

Assume an interest rate of 0%

(c) **(LO 1a)** (*5 points*) Calculate the Expected Nikkei 225 Index Return in year 7 if the present value of future profit YYG expects to earn for this product is 0. Show all work, including writing out relevant formulas used in any calculations

The response for this part is to be provided in either the ANSWER box below or in the Excel document

ANSWER:

4. Continued

(d) **(LO 1a)** (*2 points*) To improve competitiveness, the Marketing Officer has proposed a new voluntary reset feature for the GMAB rider:

"Policyholders are allowed a one-time reset of the GMAB guarantee to the current fund level at any time prior to maturity. If the reset is exercised, the maturity date of the Variable Annuity policy is reset to 7 years from the exercise date."

(i) Describe the additional risks YYG may face by adding this feature.

(ii) Recommend possible ways to mitigate these risks.

ANSWER:

NO LONGER RELEVANT

~~(e) (*2 points*) Critique the following statement from YYG's ALM department.~~

~~*"For this product we recommend dynamically hedging delta and rho by rebalancing our hedge portfolio daily to ensure a close match. We are confident this is a cost-effective way to eliminate all risk for the company."*~~

~~ANSWER:~~

1. Fall 2021 ILA LAM Exam (LOs 1a, 1c)

Relevant Sources:

CP312-101-25: Stochastic Modeling, Theory and Reality from and Actuarial Perspective, sections I.A, I.B-1.B.3.a, I.B.4, and III

(*9 points*) *ABC* Life, which sells both life and annuity products, has recently begun developing a stochastic model to address regulatory requirements and their risk analysis needs. ABC has documented the following observations and decisions during development.

(a) **(LOs 1a, 1c)** (*4 points*) Critique the following statements:

A. *While the stochastic model will be useful for calculating the average outcome, there is no reliable method for analyzing tail risks given the low probability of them occurring.*

ANSWER:

B. *We will be able to gain a better understanding of our existing single scenario stress test results by comparing with the stochastic distribution of results.*

ANSWER:

C. *We assume a normal distribution for the variables projected by the stochastic model, as the normal distribution is relatively easy to use and therefore less risky than assuming a more complex distribution.*

ANSWER:

D. *10,000 scenarios should be produced each time the model is run, because having more scenarios always provides additional information about the shape of the distribution.*

ANSWER:

1. Continued

E. The model's input parameters are calibrated using the past 2 years of historical experience, about 100 data points in total.

ANSWER:

F. During model validation, it is normal to see the stochastic mean being more than double the deterministic best estimate.

ANSWER:

1. Continued

NO LONGER RELEVANT

~~ABC Life sells a disability income rider that pays an additional benefit of 850 in years where a policyholder is disabled. In addition, an expense of 50 will be incurred in the year where a policyholder changes from active to disabled status.~~

~~The stochastic model uses a 2-state non-homogeneous Markov Chain to determine disability payments, where State 1 is Active and State 2 is Disabled. Below is the transition probability matrix used:~~

$$Q = \begin{bmatrix} 0.9 & 0.1 \\ 0.3 & 0.7 \end{bmatrix}$$

~~A Linear Congruential Generator (LCG) is used within the stochastic model to generate random uniform variables to determine the initial status of each policyholder and has the following parameters:~~

- ~~Multiplier = 2~~
- ~~Increment = 5~~
- ~~Modulus = 11~~
- ~~Initial Seed = 88~~

~~Policyholder *i* will start in the Active state if the generated corresponding sequence is less than 0.80.~~

~~(b) (*5 points*)~~

~~(i) (*2 points*) Calculate the active or disabled status generated by the uniform random number sequence for the first 4 policyholders. Show all work.~~

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

~~(ii) (*3 points*) You are also given that:~~

- ~~The LCG model generated 0.727 for policyholder X at time 0~~
- ~~Discount rate of 5%~~
- ~~All cashflows are at the beginning of year~~

~~Calculate the time 0 actuarial present value of payments caused by this rider over the next two periods.~~

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

2. Fall 2021 ILA LAM Exam (LOs 3a, 3b)

Relevant Sources:

ASOP 56: Modeling, Dec 2019, pp. 1-9

The Importance of Centralization of Actuarial Modeling Functions, Part 1: Focus on Modularization and Reuse, The Modeling Platform, Nov 2019

(*10 points*) XYZ Insurance has hired you as a consultant to review aspects of their Modeling function and Assumption Governance Framework.

(a) **(LO 3a)** (*2 points*) XYZ uses a compliance-based Assumption Governance framework with the main objective of satisfying regulatory requirements.

(i) (*1 point*) Critique the use of a compliance focused approach to Assumption Governance.

ANSWER:

(ii) (*1 point*) Recommend an alternative Assumption Governance framework for XYZ and describe the benefits they would realize.

ANSWER:

(b) **(LOs 3a, 3b)** (*4 points*) XYZ's modeling function is decentralized into small teams that independently maintain a model for each product. XYZ would like to create a centralized modeling function to improve efficiency, with a specific focus on optimizing new product development.

(i) (*2 points*) Recommend the approach XYZ should follow when creating their centralized modeling function. Justify your answer.

ANSWER:

(ii) (*2 points*) Identify the relevant considerations and recommended practices of ASOP 56 that XYZ needs to consider when creating the centralized modeling function. Justify how they apply to XYZ's approach.

ANSWER:

2. Continued

(c) NO LONGER RELEVANT

(*4 points*) XYZ's stochastic modeling group is reviewing their modeling approach for a group of Universal Life policies. You are given the following dataset:

Distance Matrix					
Policy #	**1**	**2**	**3**	**4**	**5**
1	0	1,119	561	30	4,451
2	1,119	0	1,680	1,122	3,336
3	561	1,680	0	558	5,011
4	30	1,122	558	0	4,453
5	4,451	3,336	5,011	4,453	0

Policy #	**Plan Code**	**Face Amount**	**Account Value**	**Reserves**
1	105	1,500	110	555
2	105	2,000	240	1,111
3	105	5,000	25	250
4	209	1,000	80	555
5	209	5,000	350	2,500

Critique the recommendations made in the report. Justify your answer.

A. Introducing segment boundaries is not advised as it will increase run time and add more constraints.

ANSWER:

B. When mapping policies, we start with the pair with the lowest distance (i.e. policy pair #1 and #4) and map to the policy with higher face amount between the pair (i.e. map policy #4 to policy #1).

ANSWER:

2. Continued

C. When there are pairs with similar distance (such as policy pairs #1 and #3 and policy pairs #3 and #4), to avoid bias, the company can use a random number generator to determine which pairs of policies should be mapped first.

ANSWER:

D. The UL cluster model is calibrated and uses the same weights for account value as the variable annuity cluster model with compression ratio of 50-to-1.

ANSWER:

E. A small cluster model size is preferred over larger cluster model sizes.

ANSWER:

4. Fall 2021 ILA LAM Exam (LOs 1a, 2a)

Relevant Sources:

Metamodeling for Variable Annuities, Valdez, Emiliano and Gan, Guojun

- Chapters 1-3, 6

CP312-101-25: Stochastic Modeling, Theory and Reality from and Actuarial Perspective, sections I.A, I.B-1.B.3.a, I.B.4, and III

Economic Scenario Generators: A Practical Guide, SOA, Jul 2016, Ch. 1, 2, 4.1-4.3, 5, 6, 7.1-7.3, 8

(*11 points*) Company QRF uses its own Economic Scenario Generator (ESG) to project real world scenarios for capital stress testing and risk-neutral scenarios to value the stochastic cost of guarantees on Universal Life products with guaranteed minimum crediting rates.

(a) **(LO 2a)** (*3 points*) Critique the following statements from QRF's Model Risk Management group regarding the ESG model.

A. The real-world scenarios can provide more intuitive results than the risk-neutral scenarios

ANSWER:

B. Correlation between modeled economic and financial market variables are set and held constant at model development.

ANSWER:

C. Spread inputs for a real estate investment trust in our portfolio were not readily available in the market. The actuary estimated the spreads based on fixed income bond spreads from an Oil & Gas bond with the same term-to-maturity.

ANSWER:

D. The model is calibrated using historical data from 2010 to 2019.

ANSWER:

4. Continued

You are given projected reserves under 10 scenarios sets, which used scenario reduction techniques:

Scenario Set #	Reserves with minimum crediting rate guarantee	Reserves without minimum crediting rate guarantee
1	120	100
2	150	135
3	200	150
4	170	150
5	80	45
6	95	60
7	45	45
8	250	200
9	300	250
10	350	300

The closed form solution is 32.1 for the cost of guarantee

(b) **(LO 1a)** (*3 points*)

(i) Calculate the market-consistent value of the cost of guarantee.

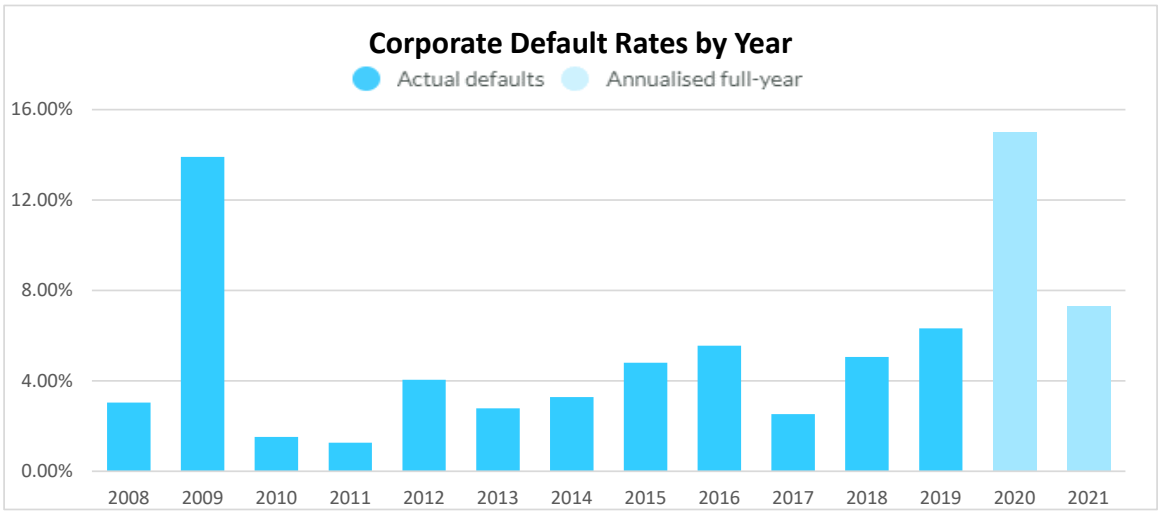
The response for this part is to be provided in the Excel spreadsheet.

(ii) Using a quantitative measure, analyze the appropriateness of the scenario reduction techniques. Recommend changes if needed.

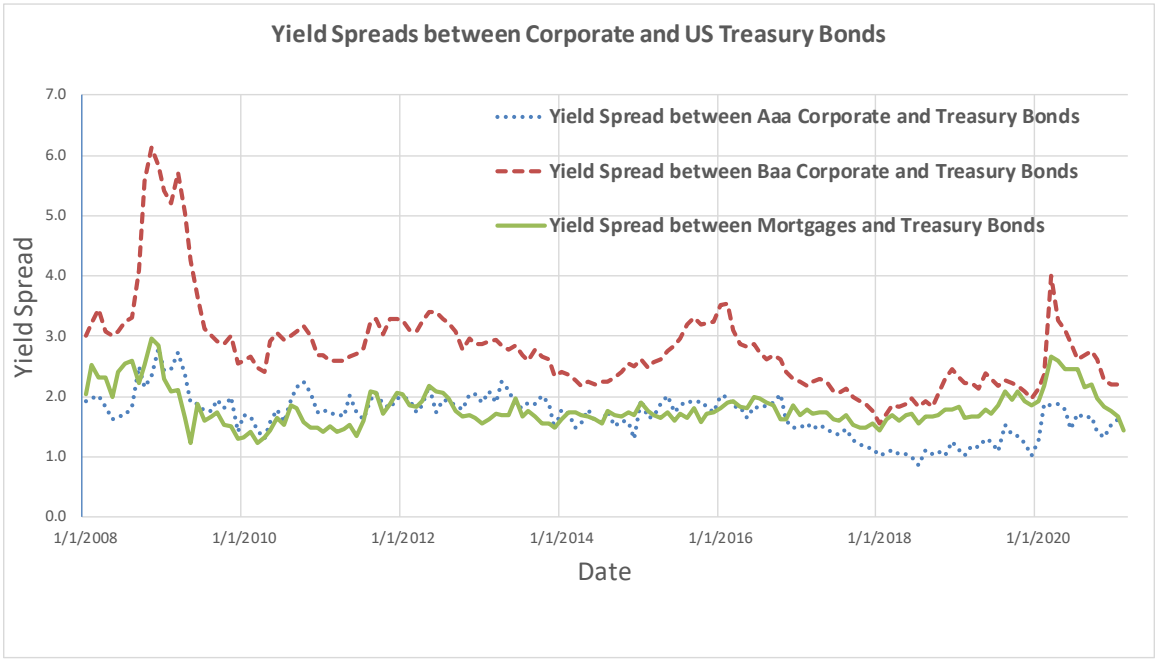
The response for this part is to be provided in the Excel spreadsheet.

4. Continued

You provided your actuarial student the following charts to analyze impacts on the ESG parameters.

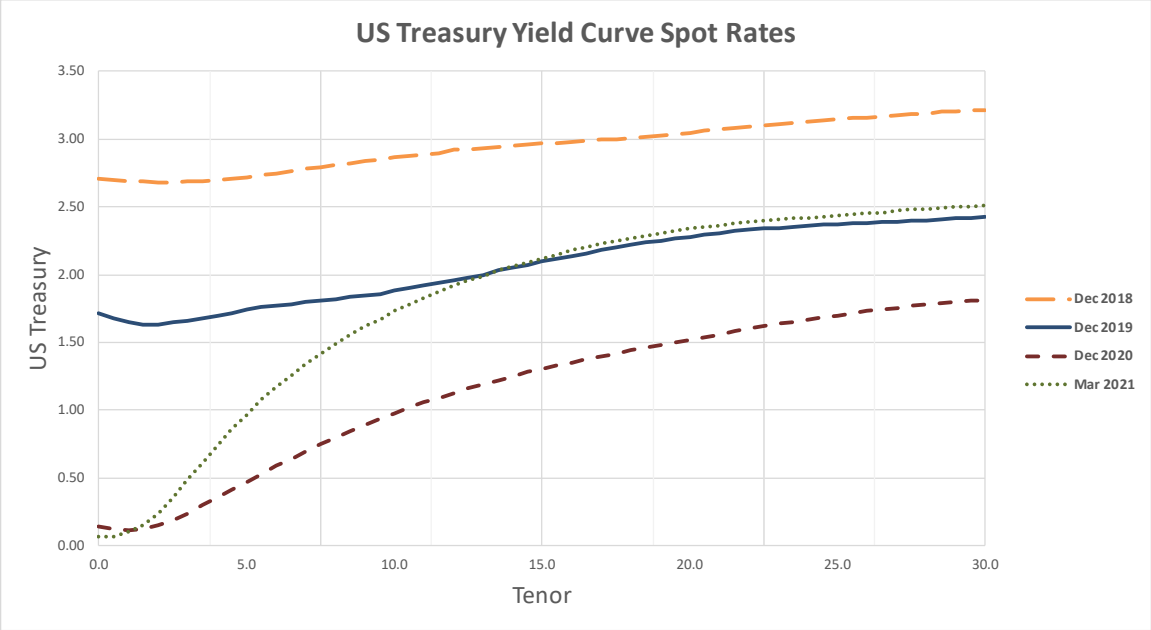


Corporate defaults are expected to decline in 2021 after a sharp rise in 2020. Forecasts project that the default rate will peak at 7.3% in March 2021, and then decline to 4.7% by December.



4. Continued

The COVID-19 outbreak has led to significant financial market disruption that has resulted in a marked increase in corporate bond spreads. By March 2021 Corporate spreads have completely recovered and are back to pre-pandemic levels.



(c) **(LO 2a)** (*5 points*) Your student complied the following list of observations and considerations. Assess each of the findings.

A. Probabilities of default will rise with general economic conditions as evidenced in 2009 and 2020.

ANSWER:

B. Widening corporate spreads will always track realized default rates.

ANSWER:

C. Corporate spreads gross of defaults fluctuated more because of 2008 and 2020 recessions.

ANSWER:

4. Continued

D. Baa rated corporate spreads are much more volatile than the Aaa rated bonds as economic condition changes.

ANSWER:

E. Based on the yield curve from different periods, it is safe to assume interest rates can be floored at 0.

ANSWER:

F. We experienced inverted yield curve from Dec 2019 to Dec 2020 because all points on the yield curve have decreased.

ANSWER:

G. Choosing a 10 year look back period for the study is reasonable as it would capture the COVID-19 impact, and therefore produces reasonable stylized facts.

ANSWER:

1. Spring 2022 ILA LAM Exam (LO 1a)

Relevant Sources:

CP312-101-25: Stochastic Modeling, Theory and Reality from and Actuarial Perspective, sections I.A, I.B-1.B.3.a, I.B.4, and III

(*10 points*)

(a) NO LONGER RELEVANT

~~(*3 points*) ABC Life is planning to develop a set of first principles mortality assumptions for its block of Long-Term Care (LTC) business. Mortality is the only decrement for this business. LTC mortality experience and the legacy total life mortality assumption are provided in the excel workbook.~~

~~Recommend an appropriate approach ABC should use to develop its first principles LTC mortality assumption. Justify your answer.~~

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

(b) **(LO 1a)** (*3 points*) Due to the impact of the COVID-19 pandemic on insurance and economic experience, ABC Life has decided to develop stochastic mortality and interest rates models.

(i) (*1 point*) Explain how stochastic modeling could improve ABC's understanding of its COVID-19 driven mortality risk compared to deterministic modeling.

ANSWER:

NO LONGER RELEVANT

~~(iii) (*2 points*) You use the newly developed stochastic mortality model to generate loss results from 10,000 simulated scenarios (provided in the Excel workbook).~~

~~Prepare a report for senior management which summarizes the conclusions which can be drawn from the model with respect to ABC's risk and capital profile.~~

~~No calculations are required for this part.~~

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

1. Continued

(c) **(LO 1a)** (*4 points*) ABC Life is developing assumptions for its stochastic interest rate model and is faced with the choice between using risk-neutral and real-world scenarios

(i) (*2 points*) Recommend the appropriate scenario choice for each of the following situations. Justify your answer.

A. Management wants to determine the market-consistent view of liabilities under a stressed interest rate environment due to the global pandemic.

ANSWER:

B. Management wants to know how much capital is needed to absorb the potential earnings loss in the current low interest rate environment.

ANSWER:

C. To calculate the hedging cost when pricing a new Universal Life product with a minimum crediting rate guarantee.

ANSWER:

D. When monitoring residual market risk of a Universal Life product with a minimum crediting rate guarantee.

ANSWER:

(ii) (*2 points*) Critique the following statement:

Short-term risk-free interest rates calculated using risk-neutral stochastic scenarios will be more conservative than those calculated using real-world scenarios.

ANSWER:

2. Spring 2022 ILA LAM Exam (LO 1a)

Relevant Sources:

Long-Term Actuarial Models Part II, Cardinal, Timothy, Cardinalis 1 LLC, 2024

- Ch. 9 Fixed and Fixed Indexed Annuities, including workbooks

(*10 points*)

(a) **(LO 1a)** (*3 points*) You are the lead pricing actuary of your company's fixed annuity product lines. Senior management has expressed concerns over the risk of a prolonged low-interest rate environment and the risk of a market correction resulting in a sudden upward spike in interest rates

(i) (*2 points*) Analyze how your company's profitability may be impacted under each of the two scenarios.

ANSWER:

(ii) (*1 point*) Propose two strategies that the company could apply to mitigate interest rate risk on its fixed annuity products.

ANSWER:

(b) NO LONGER RELEVANT

~~(*7 points*) As part of your periodic review of modeling assumptions and simplifications, you are assessing if a new method of defining issue age bands in your pricing model would be appropriate.~~

~~(i) (*2 points*) Describe the principles of professionalism outlined in *Application of Professional Judgement by Actuaries,* in the context of assumption setting.~~

~~ANSWER:~~

2. Continued

You are testing five age band definitions of varying size. The associated modeling error arising from each case is summarized below:

Case	# of Issue Age Bands	Age Error (in years)	Average Known Error	Average Unknown Error
1	15	0.1	0.5%	0.6%
2	10	0.6	3.2%	2.3%
3	8	0.7	1.2%	1.4%
4	4	0.0	0.8%	0.4%
5	3	0.4	2.4%	2.0%

Age error is defined as the weighted average difference between the weighted average issue age for each band as compared to the model issue age for that band.

(ii) (*2 points*) Assess the implications of this analysis and recommend which case(s), if any, should be further considered for implementation.

ANSWER:

(iii) (*2 points*) Your pricing model assumes the issue age of the policy is the mid-point of the age band and all age bands are of uniform width. Your manager suggests that this approach could be applied to all pricing models in the company as it is the simplest to implement.

Critique the above suggestion.

ANSWER:

(iv) (*1 point*) Compare and contrast static and dynamic model validation.

ANSWER:

1. Fall 2022 ILA LAM Exam (LOs 1c, 2a, 2c)

Relevant Sources:

CP312-103-25: Chapter 8 of Quantitative Enterprise Risk Management, Hardy, Mary and Saunders, David, 2022 (8.1-8.6)

CP312-101-25: Stochastic Modeling, Theory and Reality from and Actuarial Perspective, sections I.A, I.B-B.2, I.B.3.a, II.B-B.1.d

(*11 points*) Company HLC offers a variable annuity and is considering stochastic model options to project equity returns.

You are given the following information for a European call option:

Variable	Value
S(0), the current price of the underlying	100
K, the strike price of the option	100
T, the time until option maturity	1 year
σ, the volatility of the underlying	20.0%
d, the dividend rate of the underlying	0%

The following continuous-time Monte Carlo simulations were performed for the underlying stock price S(T), where $S(T)=S(0) * \exp[(r-\sigma^2/2) * T + \sigma * \varepsilon * T^{1/2}]$

Simulation	ε_i	$S_i(1)$
1	-1.7701	70.19
2	-0.7908	85.37
3	-0.3590	93.07
4	0.8190	117.80
5	-0.5828	89.00
6	0.7156	115.39
7	-0.3182	93.83
8	0.9314	120.48
9	1.2897	129.43
10	0.5930	112.59

1. Continued

(a) **(LOs 2a, 2c)** (*4 points*) With respect to the Monte Carlo simulation:

(i) Calculate the Monte Carlo estimate of the call option

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

(ii) Calculate the Monte Carlo sampling standard error of the estimated call option price

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

(iii) Evaluate the reasonableness of the estimated call option price

ANSWER:

(iv) Explain why a company would want to use a variance reduction technique

ANSWER:

(b) **(LO 1c, 2c)** (*4 points*) Your company would like to explore the use of a nested stochastic model to project equity returns.

(i) Explain how a nested stochastic model could be implemented

ANSWER:

(ii) Discuss the advantages and disadvantages of two possible methods that could be used to manage the run-time of the model

ANSWER:

1. Continued

(c) **(LO 2a)** (*3 points*) Critique the following statements:

A. For the underlying index, the volatility parameter is an average of 65 years of data; therefore, the credibility of such a long sample period means it is reasonable to set σ to 20% for all nodes in the model.

ANSWER:

B. The relation between interest rates and equity returns has been proven beyond statistical doubt. Consequently, in reserve calculations the expected return on equities should exceed the risk-free rate by an expected risk premium at every time step in every scenario.

ANSWER:

C. Stock prices are distributed normally and therefore the company can use the stock price volatility as a parameter in a stochastic model.

ANSWER:

2. Fall 2022 ALM LAM Exam (LOs 2a, 3b)

Relevant Sources:

Economic Scenario Generators – three-part series, SOA:

- Part III – In-depth ESG Case Study – Academy Interest Rate Generator, The Modeling Platform, Jul 2021

The Importance of Centralization of Actuarial Modeling Functions, Part 1: Focus on Modularization and Reuse, The Modeling Platform, Nov 2019

Model Validation for Insurance Enterprise Risk and Capital Models, 2014 (excluding Appendices)

(*8 points*)

(a) **(LO 3b)** (*2 points*) You oversee new product modeling at ABC Life Insurance Company. ABC is looking to develop a cost effective and controlled environment for modeling.

Critique the following two statements:

A. To save time and effort a new product will be developed using a decentralized approach where a copy of an existing model will be created for the new product and maintained separately.

ANSWER:

B. To avoid replicating errors in the existing model, new products will always need to be developed from first principles.

ANSWER:

2. Continued

(b) NO LONGER RELEVANT

~~(*5 points*) ABC is growing quickly and it is becoming more challenging to manage assumption governance requirements. You have been asked to replace the current compliance focused framework with a strategic assumption governance framework.~~

~~(i) List four beneficial byproducts of having a strategic assumption governance framework.~~

~~ANSWER:~~

~~(ii) Recommend improvements to each of the following assumption governance requirements, if necessary. Justify your recommendations.~~

~~*A. The top priority of assumption governance is compliance with regulatory requirements.*~~

~~ANSWER:~~

~~*B. All models must have consistent assumptions.*~~

~~ANSWER:~~

~~*C. Each assumption must be reviewed annually.*~~

~~ANSWER:~~

~~*D. Assumptions should only be passed to modelers for implementation after they have been approved by all relevant stakeholders.*~~

~~ANSWER:~~

2. Continued

(c) **(LO 2a)** (*1 point*) Your manager has suggested to use the interest rate model developed by the American Academy of Actuaries (the Academy model) for the pricing of new products.

Assess if this is reasonable. Justify your response.

ANSWER:

4. Fall 2022 ALM LAM Exam (LO 2a)

Relevant Sources:

Economic Scenario Generators: A Practical Guide, SOA, Jul 2016, Ch. 1, 2, 4.1-4.3, 5, 6, 7.1-7.3, 8

CP312-103-25: Chapter 8 of Quantitative Enterprise Risk Management, Hardy, Mary and Saunders, David, 2022 (8.1-8.6)

(*10 points*) The risk team at your company is looking to build an Economic Scenario Generator (ESG) to support the risk management of Variable Annuity (VA) products with minimum financial guarantees.

Instead of designing new software, your manager has proposed using the risk-neutral, market consistent ESG used by your pricing area. In your manager's report they provide the following rationale for their proposal.

(a) **(LO 2a)** (*4 points*) Critique the following statements from their report:

A. The ESG produces thousands of scenarios covering a wide distribution of projected interest rate and equity growth paths so it is ideal for risk management applications.

ANSWER:

B. The pricing department follows industry-leading practices to calibrate their ESG to current market conditions, producing near-perfect replication of option prices.

ANSWER:

C. The ESG output is regularly tested to verify the absence of arbitrage opportunities.

ANSWER:

D. If a new ESG is built for risk management, then for the sake of consistency between the inner loops and outer loops of nested scenarios the company should also use the new ESG for pricing.

ANSWER:

4. Continued

NO LONGER RELEVANT

~~Your company sells a 3-year Variable Annuity with a Guaranteed Minimum Accumulation Benefit (GMAB). The GMAB resets at the end of each year if the account value is greater than the guarantee value.~~

~~You are given the following:~~

~~Opening Account Value~~	~~100,000~~
~~Opening Guarantee Value~~	~~100,000~~
~~Rider Fee, collected at end of each year~~	~~3%~~

~~Assume no other fees, decrements, or expenses.~~

~~Your risk department proposes the following hedging strategy:~~

- ~~At the beginning of each year, purchase a 1-year at the money put option with notional equal to the beginning of year account value~~
- ~~The cost per 1,000 of notional is 25~~

~~(b) (*5 points*) Calculate the expected profit and loss for the product under each of the following scenarios:~~

~~(i) The underlying equity index earns 5% per year~~

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

~~(ii) The underlying equity index earns -5% per year~~

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

~~(c) (*1 point*) Your manager has expressed a concern that the proposed product is too risky and despite the proposed risk mitigation the company could be exposed to significant claim costs if markets decrease.~~

~~Recommend changes to the hedging strategy to address your managers concerns.~~

~~ANSWER:~~

1. Spring 2023 ILA LAM Exam (LOs 2a, 3a)

Relevant Sources:

Economic Scenario Generators: A Practical Guide, SOA, Jul 2016, Ch. 1, 2, 4.1-4.3, 5, 6, 7.1-7.3, 8

ASOP 56: Modeling, Dec 2019, pp. 1-9

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

(a) NO LONGER RELEVANT

~~(*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)~~

	~~**Economic Scenario**~~	~~**Asset / Liability**~~
~~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) **(LO 2a)** (*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) **(LO 3a)** (*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:

5. Spring 2023 ILA LAM Exam (LO 2a)

Relevant Sources:

CP312-101-25: Stochastic Modeling, Theory and Reality from an Actuarial Perspective, sections I.A, I.B-B.2, I.B.3.a, II.B-B.1.d

CP312-106-25: Catastrophe Modelling: Guidance for Non-Catastrophe Modelers

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

(a)

NO LONGER RELEVANT (~~*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) **(LO 2a)** (*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:

5. Continued

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) **(LO 2a)** (*2 points*) Assess if the proposed capital amount is sufficient to cover expected losses at the 90^{th} percentile. Justify your answer.

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

6. Spring 2023 ILA LAM Exam (LO 3a)

Relevant Sources:

Model Validation for Insurance Enterprise Risk and Capital Models, CAS/CIA/SOA 2014 (excluding Appendices)

ASOP 56: Modeling, Dec 2019, pp. 1-9

(*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) **(LO 3a)** (*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) **(LO 3a)** (*2 points*) Identify additional documentation required from MYB and your company to ensure effective model risk control.

ANSWER:

1. Spring 2024 ILA LAM Exam (LO 2a)

Relevant Sources:

Economic Scenario Generators: A Practical Guide, SOA, Jul 2016, Ch. 1, 2, 4.1-4.3, 5, 6, 7.1-7.3, 8

CP312-103-25: Chapter 8 of Quantitative Enterprise Risk Management, Hardy, Mary and Saunders, David, 2022 (8.1-8.6)

CP312-101-25: Stochastic Modeling, Theory and Reality from an Actuarial Perspective, sections I.A, I.B-B.2, I.B.3.a, II.B-B.1.d

(*8 points*) Your company is reviewing and updating various models used across the organization.

(a) **(LO 2a)** (*2 points*) Critique the following statements regarding stochastic modeling:

(i) *Stochastic models should only be used when it is explicitly required by a regulatory standard.*

ANSWER:

(ii) *Real-world scenarios cannot be connected with risk-neutral scenarios due to different usage of expected cash flows and a discount rate.*

ANSWER:

(iii) *For nested stochastic modeling, real-world scenarios and risk-neutral scenarios should be used for inner-loop and outer-loop, respectively.*

ANSWER:

~~(iv)~~ **NO LONGER RELEVANT** ~~*When using a random number generator, a true random number generator is more efficient than a pseudo random number generator.*~~

~~ANSWER:~~

1. **Continued**

(b) NO LONGER RELEVANT

~~(*3 points*) A Generalized Linear Model (GLM) is due for an update. The following data is provided regarding claim severity:~~

	~~**Smoker**~~	~~**Non-smoker**~~
~~Male~~	~~900~~	~~500~~
~~Female~~	~~600~~	~~400~~

~~The form of the GLM is:~~

$$~~Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon~~$$

~~Where:~~

~~β_1 = Parameter for Male~~
~~β_2 = Parameter for Female~~
~~β_3 = Parameter for Smoking Status~~

~~(i) (*2 points*) Solve for parameters β_1, β_2 and β_3 assuming the error term is normally distributed with mean zero and variance σ^2.~~

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

~~(ii) (*1 point*) Evaluate the limitations of the use of a normal error structure.~~

~~ANSWER:~~

(c) **(LO 2a)** (*3 points*) Your company uses a normal distribution with constant volatility to project equity returns.

(i) (*1 point*) Describe a drawback of using the normal distribution with constant volatility to project returns.

ANSWER:

(ii) (*2 points*) Recommend two possible alternatives to using constant volatility. Justify your answer.

ANSWER:

5. Spring 2024 ILA LAM Exam (LO 2a)

Relevant Sources:

Economic Scenario Generators: A Practical Guide, SOA, Jul 2016, Ch. 1, 2, 4.1-4.3, 5, 6, 7.1-7.3, 8

(*11 points*) You are developing an economic scenario generator (ESG) to be used to model interest rates for hedging a block of variable annuities.

(a) **(LO 2a)** (*4 points*) Critique the following statements:

A. *Interest rate modeling is not as complex as stock price modeling as the term structure of interest rates only requires modeling a single variable.*

ANSWER:

B. *It is not sufficient to treat the risk-free rate as a fixed parameter. An ESG that is being used for the management of variable annuity risk would need to include model dynamics that capture the path wise features of interest rates.*

ANSWER:

C. *Arbitrage-free models are a necessary requirement when one wants to apply an ESG to real-world scenarios. If the scenarios are not arbitrage-free, then one cannot consistently price derivatives.*

ANSWER:

D. *Only risk-neutral scenarios are used for hedging variable annuities.*

ANSWER:

(b) **(LO 2a)** (*1 point*) Describe the purpose of establishing Stylized Facts prior to the development of the ESG.

ANSWER:

5. Continued

Management is not convinced about the use of an ESG and recommends using analytical solutions which do not require intensive computation.

(c) **(LO 2a)** (*2 points*) Critique management's recommendation.

ANSWER:

NO LONGER RELEVANT

~~The company sells a variable annuity with a guaranteed minimum accumulation benefit (GMAB). You are given:~~

~~**Risk-free interest rate**~~	~~3%~~
~~**Account value**~~	~~100,000~~
~~**Guarantee value**~~	~~100,000~~
~~**Ratchet**~~	~~Annual~~
~~**Maturity**~~	~~10 years~~

~~The account value will either increase or decrease by 8% each year. Assume no other fees, decrements, or expenses.~~

~~(d) (*2 points*) Calculate the risk neutral probability of the account value increasing by 8% in a given year.~~

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

5. Continued

(e) (*2 points*) State if the following concepts are illustrated in the model used in part (d). Justify your answer.

(i) Replication

ANSWER:

(ii) No-arbitrage assumption

ANSWER:

(iii) Risk neutral probability distribution

ANSWER:

(iv) Dynamic hedging

ANSWER:

Question 3 pertains to the Case Study.
Each question should be answered independently.

https://www.soa.org/4a27ab/globalassets/assets/files/edu/2024/fall/case-study/cfefd.pdf

3. Fall 2024 CFE FD Exam (LO 2b)

Relevant Sources:
CP312-108-25: Chapter 15 of Measuring Market Risk, Dowd, Kevin, 2nd Edition, 2005
Case Study - Darwin

(*11 points*) Darwin Life (Case study section 6) has suffered net losses in its Variable Annuity (VA) product in the second half of 2023 due to the major movements in equities and interest rates shown below.

Actual macro environment	**3Q 2023**	**4Q 2023**
interest rates	up 75 bps	down 115 bps
equity markets	down 9%	up 16%

The CRO, Aaliyah Jackson, has asked for an analysis of the risk models Darwin has been using.

(a) **(LO 2b)** (*2 points*)

(i) Describe the two bases for statistical backtests that can be used to assess the adequacy of the risk models.

ANSWER:

(ii) Identify an advantage, in addition to ease of application, and a disadvantage for each basis in part (i).

ANSWER:

3. Fall 2024 Continued

To respond to the CRO, data on Profit and Loss (P/L) observations and statistics from the models are analyzed over the 2nd half of 2023, which had 125 trading days. The current risk models assume P/L is normally distributed. Data is provided in the Excel tab CFE FD F24 Q3b.

(b) **(LO 2b)** (*4 points*)

(i) Construct a backtesting chart based on the Excel data.

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

(ii) Interpret the results in the context of Darwin's VA hedging program.

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

You are considering using the Rosenblatt and Berkowitz Transformations.

(c) **(LO 2b)** (*5 points*)

(i) Explain the Transformations, their purpose, and application.

ANSWER:

(ii) Transform the data to populate the two charts provided in the Excel tab CFEFD F24 Q3c.

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

(iii) Interpret the results of the Transformations for Darwin Life.

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

3. Spring 2024 CFE FD Exam (LO 2b)

Relevant Sources:
CP312-108-25: Chapter 15 of Measuring Market Risk, Dowd, Kevin, 2nd Edition, 2005

(~~*8 6 points*~~) Hibiscus Insurance Company is evaluating a newly issued stock to add to the equity portfolio. John, an ALM manager, is developing a risk prediction model for the stock. He has obtained two sets of data with a 1-year horizon of that stock, one from the accounting department and another from the investment department.

~~Emily, an analyst, suggests that John should use the investment department data.~~

~~Emily also observes that intraday movement will affect data accuracy.~~

~~(a) (*1 point*)~~

~~(i) Assess Emily's suggestion to use the investment department data.~~

~~ANSWER:~~

~~(ii) Recommend two methods to address the issue with data accuracy.~~

~~ANSWER:~~

3. Spring 2024 Continued

The purpose of back testing is to validate the risk prediction model before the model is being used to predict return in the future. This involves applying a quantitative method to judge whether the actual investment P/L data are consistent with the proposed model assumption.

(a) **(LO 2b)** (~~*2 1 points*~~)

(i) Describe the purpose of back-testing in this context.

ANSWER:

~~(ii) Explain which CRISP-DM stage the back testing procedure belongs to.~~

~~ANSWER:~~

John proposes a standard normal model with Rosenblatt Transformation for back testing.

(b) **(LO 2b)** (*5 points*)

(i) Perform the Rosenblatt Transformation on the data provided in Excel tab Q3_c. Show your work.

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

(ii) Determine if the null hypothesis can be accepted. Justify your answer.

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

1. Fall 2023 CFE FD Exam (LOs 2a, 2b)

Relevant Sources:
CP312-108-25: Chapter 15 of Measuring Market Risk, Dowd, Kevin, 2nd Edition, 2005

CP312-107-25: A Financially Justifiable and Practically Implementable Approach to Coherent Stress Testing

(~~8~~ *6 points*) CBA Insurance's Chief Risk Officer (CRO) is interested in understanding CBA's risk exposure, the company's financial breaking point, and the impact of a worst-case scenario. You have been tasked with using stress testing on CBA's financial model to address the CRO's concerns.

(a) **(LO 2a)** (*2 points*) Describe two benefits and two difficulties of stress testing.

ANSWER:

(b) **(LO 2a)** (*1 point*) Recommend a specific stress-testing approach that addresses the CRO's concerns. Justify your recommendation.

ANSWER:

~~Your manager has recommended the use of Value at Risk (VaR) as opposed to stress testing to gauge the risks to the company in crisis situations.~~

~~(c) (*2 points*) Evaluate your manager's recommendation.~~

~~ANSWER:~~

1. Fall 2023 Continued

At a later date, you are tasked with conducting a Basic Frequency Backtest of the financial model's daily end-of-day Profit and Loss. The results of the Backtest are below.

Number of Days in Period	600
Number of Observations with Profits above the Upper Risk Bound (VaR at the 5% confidence level)	36
Number of Observations with Losses below the Lower Risk Bound (VaR at the 95% confidence level)	40

(~~d~~c) **(LO 2b)** (*3 points*)

(i) Describe one advantage and one disadvantage of a Basic Frequency Backtest.

ANSWER:

(ii) Interpret the results of the Backtest from the table above.

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

5. Spring 2023 CFE FD Exam ((LOs 1d, 2c)

Relevant Sources:
CP312-102-25 Heavy Models, Light Models and Proxy Models Ch. 1-5

(~~*12*~~ *10 points*) You are an actuary working in the ERM department of a large insurance carrier, and you plan to develop a stochastic model to calculate the solvency capital requirements for the company for a term life insurance product.

(a) **(LO 1d, 2c)** (*1 point*) Describe one advantage and one disadvantage of stochastic models.

ANSWER:

You have determined a proxy model will be used for the calculations. Management prefers a proxy model where the individual risk components (e.g., interest rate, mortality, lapse, and credit spread) can be optimized. The following proxy formulas are being considered for the model:

- Replicating Portfolios
- Replicating Polynomial
- Commutation Functions

(b) **(LO 1d, 2c)** (*2 points*)

(i) Compare and contrast the three proxy formulas across the following:

I. Formula structure
II. Regression versus interpolation
III. Optimization

ANSWER:

(ii) Recommend a proxy formula that will satisfy management's preference. Justify your recommendation.

ANSWER:

5. Spring 2023 Continued

Your manager, the head of ERM, says, "A proxy model mimics the key behaviors in the heavy model, so we can rely on all the results of your proxy model at the scenario level going forward."

(c) **(LO 1d, 2c)** (*2 points*) Critique your manager's statement.

ANSWER:

1,000 calibration scenarios have been run in the selected proxy model, with the output provided in the Excel spreadsheet, CFEFD s23 Q5d. The results of the heavy model for the same 1,000 scenarios are also provided in the Excel spreadsheet.

(d) **(LO 1d, 2c)** (*1.5 points*)

(i) Calculate the 1-in-200 VaR of the calibration scenarios. Show your work.

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

(ii) Calculate the 95th Percentile Error of the proxy model. Show your work.

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

(e) **(LO 1d, 2c)** (*3.5 points*) Assess the appropriateness of the fit of the proxy model.

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

5. Spring 2023 Continued

The results of sample stress testing of the model are provided in the table below.

Risk Factor	Marginal Impact of Risk Factor
Interest Rate	5
Mortality	2
Lapse	4
Credit Spread	2.5
Combined Scenarios	15

The formula component for non-linearity between any two risks above (excluding Combined) is of the form: $c_1xy + c_2xy^2 + c_3x^2y + c_4x^2y^2$ where c_1, c_2, c_3, and c_4 are constants.

(f) (*2 points*)

(i) Calculate the Combined Non-Linearity Surface of the stress test. Show your work.

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

(ii) Determine the number of heavy lift calculations required to calibrate the formulas of each of the potential risk factor pairings. Show your work.

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

8. Spring 2023 CFE FD Exam (LO 2b)

Relevant Sources:
CP312-108-25: Chapter 15 of Measuring Market Risk, Dowd, Kevin, 2nd Edition, 2005

(~~*8 3 points*~~) Your company is interested in purchasing a competitor's existing block of fixed deferred annuities. ~~with minimum interest rate guarantees ranging from 1% to 4%. When interest rates increase rapidly, the product experiences higher than normal lapses because the product's portfolio crediting rate cannot keep up with new money crediting rates.~~

~~(a) (*1 point*) Identify two distinctive features that need to be considered in selecting a suitable stochastic process to model interest rates.~~

~~ANSWER:~~

~~You are interested in understanding projected lapses under different market conditions, and possibly applying machine learning techniques. The seller has provided historical monthly data on a set of 100,000 policies for a period of ten years. A data summary report is provided in Excel tab Q8_b.~~

~~(b) **(LO 4a, 4b)** (*1 point*) Identify two data quality issues indicated by the data summary report provided in Excel.~~

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

~~As part of evaluating the purchase of the block, the company is considering a hedge program to protect against interest rate risk. You have been asked to determine the appropriate strike prices for both interest rate caps and floors.~~

- ~~The risk tolerance level is 90% VaR of net losses, including hedge costs.~~
- ~~The distribution of net losses generated under a set of stochastic scenarios is provided in Excel tab Q8_c.~~

~~(c) (*2 points*) Describe two pros and two cons of using stress testing for this model.~~

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

8. Spring 2023 Continued

You are looking at the backtesting results of two models,

- In your current model, you observed 93 instances where the net losses exceeded your risk tolerance.
- In an industry model (based on 500 observations generated under a different distribution, but that uses the same risk tolerance metric), you observed 62 instances where the net losses exceeded your risk tolerance.

(d) **(LO 2b)** (*3 points*)

(i) Compare the two models based on backtesting results.

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

(ii) Recommend the best model to use. Justify your recommendation.

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

~~You have been asked to present the results of this analysis for decision making to the Risk Committee. You know that the Risk Committee has often taken the view that the decision should be whatever the model says.~~

~~(e) **(LO 4a, 4b)** (*1 point*) Summarize the key points that you should highlight to the Risk Committee to help them think more broadly about using model results to make decisions.~~

~~ANSWER:~~

Question 1 pertains to the Case Study.

https://www.soa.org/49af5b/globalassets/assets/files/edu/2022/fall/exams/spring-2022-exam-cfefd-case-study.pdf

1. Spring 2022 CFE FD Exam (LO 3a)

Relevant Sources:
ASOP 56: Modeling, Dec 2019, pp. 1-9

Case study

(~~*10* 1 *points*~~) You are an actuary on Darwin's risk management team (Case Study section 6) and are responsible for reviewing the economic capital model developed by Consultants-R-Us.

~~Anne Kofsky, Vice President of the Life Insurance Division, would like to understand how the sub-portfolios of the newly proposed IUL product may impact the company's profitability during a 1-in-20 year risk scenario. For this analysis she has specifically requested that you analyze the economic capital model's output at the VaR(95) loss level and use the Shapley method as your capital allocation method.~~

1. Spring 2022 Continued

(a) (*2 points*) Explain one advantage and one disadvantage for each of the following with respect to Darwin's risk management:

a. VaR(95) as the risk measure

ANSWER:

b. Shapley method as the capital allocation method

ANSWER:

(b) (*3 points*) Calculate values for the 'Shapley Value Table' using the information provided for the Current UL, IULF, and IULV portfolios in Case Study section 6.7.1. Show your work.

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

(c) (*1 point*) Explain the impact of the capital allocation from your calculation in part (b) on Darwin's overhead cost allocations.

ANSWER:

Anne later shares the results of her requested analysis with the rest of the management team at a meeting. At the meeting Anne said, "The answer is clear. Based on the analysis of the model output, we should sell more of the IUL product than the current UL".

(d) (*3 points*) Explain three reasons why Darwin would make strategic decisions that may disagree with the model results.

ANSWER:

(a) **(LO 3a)** (*1 point*) Identify four disclosures you should include in Darwin's model documentation per the requirements of ASOP 56.

ANSWER:

Question 6 pertains to the Case Study.

https://www.soa.org/4ae40b/globalassets/assets/files/edu/2021/fall/exams/fall-2021-exam-cfefd-case-study.pdf

6. Fall 2021 CFE FD Exam (LO 1d)

Relevant Sources:
CP312-102-25 Heavy Models, Light Models and Proxy Models Ch. 1-5

Case Study: Snappy Life

(*11 points*) Snappy (Case Study Section 7) has a block of simple non-participating whole life policies that contains significant mortality and interest rate risks. As the valuation actuary at Snappy, you use an old spreadsheet-based software for the insurance liability valuation, which runs slowly for large quantities of data. The model assumptions contain multiple dimensions and interdependencies.

Regulations require Snappy to run four deterministic sensitivities. To perform these sensitivity tests, you want to create a polynomial model that uses policy characteristics observed directly from policy data to approximate the reserves of the full model.

The polynomial model is in the form

$$\sum_{k=1\ldots K} \beta_k X_k(r_1(s), \ldots, r_N(s)) \quad = y(s)$$

(a) **(LO 1d)** (*1 point*) Describe the following parameters.

(i) β_k

(ii) $X_k()$

(iii) y(s)

(iv) $r_N(s)$

ANSWER:

6. Fall 2021 Continued

(b) **(LO 1d)** (*2 points*) Explain the following considerations behind developing the proxy model for Snappy:

(i) Formula structure

(ii) Data selection

ANSWER:

You determined the formula structure of the proxy model to be as follows:

$$y(s) = \beta_1 \frac{Insured\ Volume\ ('000) * Premium\ Payment\ Period}{Annual\ Premium} + \beta_2\ Age\ Function + \beta_3 \frac{Attained\ Age * Insured\ Volume\ ('000)}{1000} + \beta_4\ Cash\ Surrender\ Value$$

Where Age Function is:

$$Age\ Function = \begin{cases} If\ male\colon\ (Attained\ Age)^2 \\ If\ female\colon 0 \end{cases}$$

Using the data provided in the Excel spreadsheet:

(c) **(LO 1d)** (*4 points*) Calibrate the parameters of the proxy model using the unweighted Least Squares method. Show your work.

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

6. Fall 2021 Continued

Your supervisor does not understand how the proxy model can be used to satisfy reporting requirements and believes additional validation work is required.

(d) **(LO 1d)** (*4 points*)

(i) Explain four shortcomings of using this proxy model approach for required sensitivities.

ANSWER:

(ii) Recommend two changes to your modeling process to improve its robustness. Justify your response.

ANSWER:

Questions 4 pertains to the Case Study.
Each question should be answered independently.

https://www.soa.org/4ad260/globalassets/assets/files/edu/2020/fall/exams/edu-2020-fall-cfefd-exam-case-study.pdf

4. Fall 2020 CFE FD Exam (LOs 2a, 2b, 3a)

Relevant Sources:
CP312-108-25: Chapter 15 of Measuring Market Risk, Dowd, Kevin, 2nd Edition, 2005

CP312-109-25: Laurent, Norbert, Planchet, Chapter 7 (Sec. 7.2 only) of Modeling in

Life Insurance - A Management Perspective

ASOP 56: Modeling, Dec 2019, pp. 1-9

CP312-107-25: A Financially Justifiable and Practically Implementable Approach to Coherent Stress Testing

Case Study – RPPC, Big Ben

(*12 points*) Mr. Patel has hired you to review Big Ben's model risk (Case Study Section 6). He provides RPPC's Model Risk Framework (Case Study Section 1.3.10).

(a) **(LO 2b, 3a)** (*2 points*) Recommend two improvements to RPPC's Model Risk Management Framework to strengthen the model validation process. Justify your recommendation.

ANSWER:

4. Fall 2020 Continued

You begin your review with Big Ben's stress testing models. Patel says, "Stress tests have limited value because you don't know their likelihood."

(b) **(LO 2a)** (*2 points*) Critique Patel's statement.

ANSWER:

(c) **(LO 2a)** (*3 points*)

(i) Critique Big Ben's stress testing.

(ii) Recommend two improvements to Big Ben's stress testing. Justify your recommendation.

ANSWER:

You then turn your attention to Big Ben's backtesting results. You are concerned that you are only provided the statement: "The model has been deemed to have passed the backtesting because recent tests have shown that after-tax profits are not systematically under or over estimated."

(d) **(LO 2b)** (*2 points*)

(i) Describe two pieces of important backtesting information not provided in the above statement.

(ii) Explain how the missing information described in (i) can be a concern to Big Ben.

ANSWER:

4. Fall 2020 Continued

You request daily time series data to review the backtesting results. The following table provides forecasted and observed profits for five consecutive trading days. Profits are assumed to be normally distributed.

Observation Day	Realized P/L	Forecast Mean	Forecast Standard Deviation
T	4,065	3,250	967
T+1	4,297	5,665	1,629
T+2	2,981	2,275	838
T+3	3,505	4,051	650
T+4	2,977	1,922	1,252

(e) **(LO 2b)** (*3 points*)

(i) Interpret the backtesting results above.

(ii) Recommend whether further action is needed based on the results above. Justify your recommendation.

ANSWER:

10. Fall 2020 CFE FD Exam (LO 3a)

Relevant Sources:
ASOP 56: Modeling, Dec 2019, pp. 1-9

(~~9~~ *1 point~~s~~*) ABC Credit Card Company (ABC) wants to speed up its credit limit review by introducing a predictive model. Current practice is to manually review each customer's credit, which takes one business day. ABC's goals are to reduce average review time by 50% and to achieve 90% average class accuracy.

(a) (*1 point*) Describe two best practices recommended in Actuarial Standard of Practice No. 56 to evaluate a predictive model.

ANSWER:

~~ABC selected a portion of historical data to train a binary predictive model to categorize customers as either "Premier" or "Standard".~~

~~Below is the resulting confusion matrix when the remaining historical data are run through the predictive model as well as an estimated relative profit table based on historical data.~~

~~**2-Class Confusion Matrix**~~

-	-	Prediction ('000)		
	-	Premier	Standard	Recall
Target ('000)	Premier	120	5	0.96
	Standard	16	20	0.56
-	Precision	0.88	0.8	-

~~**Profit Matrix per Customer**~~

-	-	Prediction ('000)	
	-	Premier	Standard
Target ('000)	Premier	100	-100
	Standard	-750	50

~~If the 2-class model is accepted, customers will receive results instantaneously.~~

10. Fall 2020 Continued

ABC's CEO reviews the results and states: "The model results look great. Our main concern should be the accuracy of the Premier category because it is the most profitable and we have over three times as many customers in this category as in the Standard category."

(b) **(LO 4a, 4b)** (*3 points*)

(i) Interpret the Recall results.

(ii) Interpret the Precision results.

(iii) Critique the CEO's statement.

ANSWER:

ABC decides to refine the model to reflect its customer base. ABC builds a 5-class model using the same data to train and test the model as it used for the 2-class model. The 5-class model uses separate algorithms to break down the "Premier" and "Standard" classes.

5-Class Confusion Matrix

		Prediction ('000)					
		Premier +	Premier	Standard ++	Standard +	Standard	Recall
Target ('000)	Premier +	48	2	0	0	0	0.96
	Premier	2	72	1	0	0	0.96
	Standard ++	0	3	9	5	1	0.50
	Standard +	0	1	3	7	2	0.54
	Standard	0	0	1	1	3	0.60
	Precision	0.96	0.92	0.64	0.54	0.50	

Processing time of the 5-class model is the same as the 2-class model.

(c) **(LO 4a, 4b)** (3 *points*) Recommend a credit review approach that meets ABC's goals. Justify your recommendation.

ANSWER:

10. Fall 2020 Continued

ABC implemented the 5-class model and collected the following data samples to monitor performance.

	Original	Sample at T_1		Sample at T_2	
Target	Count	Count	Stability Index	Count	Stability Index
Premier +	50	100	0.023	150	0.045
Premier	75	150	0.034	225	0.067
Standard ++	18	90	0.061	180	0.104
Standard +	13	65	0.044	130	0.075
Standard	5	25	0.017	50	0.029
Sum	**161**	**430**	**0.179**	**735**	**0.320**

(d) **(LO 4a, 4b)** (*2 points*)

(i) Explain the downside to relying on stability index results.

(ii) Recommend next steps for ABC based on the stability index results. Justify your recommendation.

ANSWER: