SOCIETY OF ACTUARIES

Advanced Topics in General Insurance

Exam GIADV

Date: Friday, May 2, 2025

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has 13 questions numbered 1 through 13 with a total of 60 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 σ^2 can be typed as sigma^2.

   b) Calculations should be done in Excel and entered as formulas. 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. Rows can be inserted to the answer input area as required to provide space for your answer.

   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 the five-minute upload period expires.

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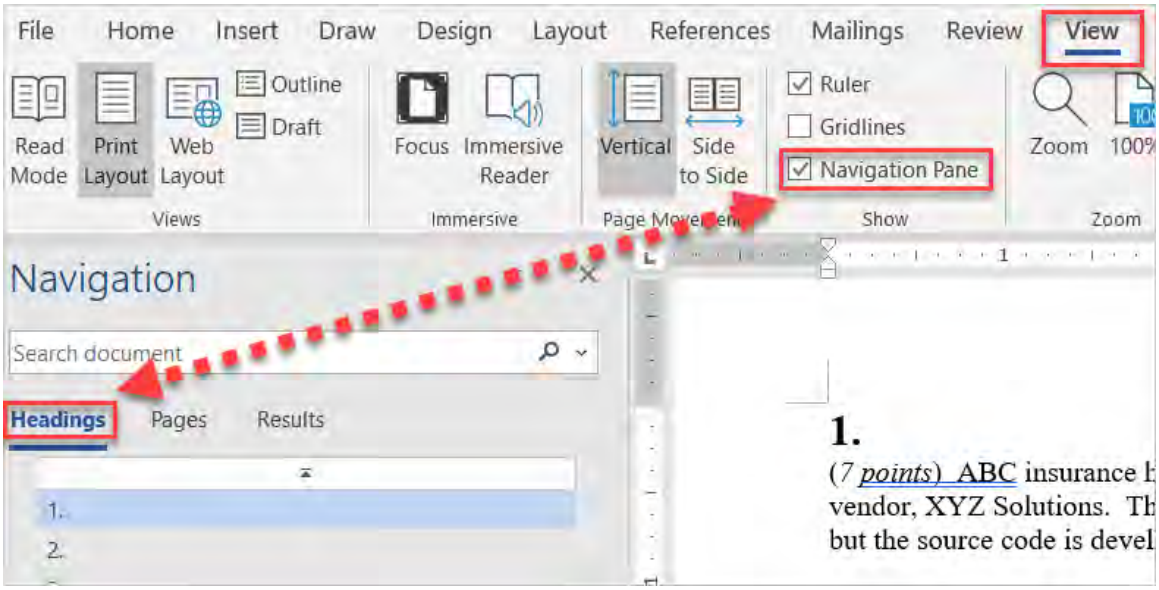
Navigation Instructions

Open the Navigation Pane to jump to questions.

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



1.

Provide the response for this question in the Excel spreadsheet.

(*4 points*) Friedland presents a list of the six principal functions of reinsurance. These include:

- Provision of technical service and expertise.
- Facilitation of withdrawal from a market segment.

(a) (*2 points*) Complete the following table (***in Excel***) based upon Friedland's six principal functions of reinsurance.

Principal Functions of Reinsurance	Suitably Addressed by Proportional Reinsurance	Suitably Addressed by Non-Proportional Reinsurance
1. Provision of technical service and expertise	Yes	Yes
2. Facilitation of withdrawal from a market segment	Yes	No
3.		
4.		
5.		
6.		

ABC Insurance writes property insurance and has the following reinsurance:

Reinsurance Treaty	Reinsurer	Description
Surplus Share	SU-Re	5 lines with a retained line of 1,000
Per Risk Excess of Loss	XS-Re	2,000 in excess of 1,000, applied after surplus share reinsurance

XS-Re priced the per risk treaty using the following exposure factors:

Percent of Total Insured Value (TIV)	Exposure Factor
0%	0%
10%	37%
20%	49%
30%	57%
40%	64%
50%	70%
60%	76%
70%	81%
80%	85%
90%	89%
100%	93%
110%	97%
120%	100%

1. Continued

XS-Re is interested in the following two properties insured by ABC Insurance:

- Property Y with a TIV of 4,000
- Property Z with a TIV of 15,000

Expected gross losses for each of properties Y and Z is 25% of the TIV.

(b) (*2 points*) Calculate XS-Re's expected losses for each property (Y and Z).

2.

Provide the response for this question in the Excel spreadsheet.

(*4 points*) You are given the following for a prospective experience rating plan:

- Forecast period is July 1, 2025 to June 30, 2026 (i.e., policy year 2025 or PY25) for application of the experience modification
- Experience rating calculations are performed using the latest three completed policy years (PY21 through PY23)
- Experience rating applies to total basic limits premium (BLP).
- The basic limit for indemnity is 20,000.
- The Maximum Single Limit (MSL) is 26,000.
- The adjusted expected loss ratio (AELR) is 0.62.
- The plan uses the same formula as the Massachusetts Commercial Automobile Experience Rating Plan.

Policy Year	BLP Subject to Experience Rating
2021	53,717
2022	61,586
2023	66,322

Reported Claims since July 1, 2021, as of March 1, 2025			
Claim ID	**Claim Date**	**Indemnity**	**ALAE**
A01	Aug 5, 2021	13,747	10,416
A02	Mar 21, 2022	18,299	4,335
A03	Jul 12, 2022	32,843	10,971
A04	Jan 23, 2023	8,266	3,584
A05	Sep 10, 2023	13,124	7,407
A06	Jun 27, 2024	26,825	6,077
A07	Oct 4, 2024	6,555	1,389

Experience Period BLP		Plan
From	**To**	**Credibility (Z)**
20,000	39,999	0.10
40,000	49,999	linear interpolation
50,000	99,999	0.25
100,000	119,999	linear interpolation
120,000	149,999	0.50
150,000	199,999	linear interpolation
200,000	and over	1.00

2. Continued

Expected Percentage of Claims Unreported by PY Development Month				
	20	**32**	**44**	**56**
Expected Unreported (%)	10.1%	2.4%	0.1%	0.0%

Calculate the experience modification for this plan. Assume that no trending procedures are used.

3.

Provide the response for this question in the Excel spreadsheet.

(*4 points*) You have been provided data extracted from a triangle of cumulative paid losses. The data are provided on tab "Q03" in the Excel file.

You plan to apply Clark's stochastic reserving model using the LDF method and are considering two distributions, exponential and Weibull.

The spreadsheet shows the work done to obtain the maximum likelihood estimates for the two distributions. You decide to use the likelihood ratio test to determine which distribution to use.

(a) (*1 point*) Determine the distribution selected by the likelihood ratio test. Show all calculations.

Regardless of the choice made, use the Weibull distribution for the remaining parts of this item.

(b) (*1 point*) Estimate the scale factor, σ^2.

(c) (*1 point*) Estimate the process standard deviation of the loss reserve for all accident years combined.

Clark notes that a key assumption is that the observations are identically distributed.

(d) (*0.5 points*) State what this assumption means in terms of the LDF method for loss development.

(e) (*0.5 points*) State one reason why this assumption is unlikely to be true.

4.

(*7 points*) You are interested in determining the variability of unpaid claim estimates. The triangle of cumulative paid claims data is presented below. It is assumed that all claims are fully developed after ten years.

Accident Year (AY)	Development Year (DY)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	30,211	75,385	103,778	125,092	140,205	150,205	157,130	161,691	163,916	164,977
2	30,536	84,818	114,669	134,659	149,903	159,451	164,287	167,498	171,395	
3	36,158	95,256	130,997	146,506	162,116	174,366	175,958	182,273		
4	32,925	87,067	124,608	145,692	163,246	172,525	187,540			
5	40,989	105,488	148,186	171,899	188,358	200,423				
6	69,781	186,243	231,924	272,681	285,100					
7	71,289	178,351	229,468	253,161						
8	57,826	146,754	190,784							
9	61,008	147,348								
10	47,792									

The data and all calculations to obtain Mack's variability estimates are provided in the Excel sheet on tab "Q04."

One of the assumptions that underlies Mack's development of an estimate of variability of chain ladder estimates is

$$E(C_{i,k+1} \mid C_{i1}, \ldots, C_{ik}) = C_{ik} f_k, 1 \le i \le I, 1 \le k \le I - 1.$$

Mack notes "the equations constitute an assumption which is not imposed by us but rather implicitly underlies the chain ladder. This is based on two aspects of the basic chain ladder equation …"

(a) (*1 point*) State the two aspects that Mack is referencing in this statement.

ANSWER:

(b) (*2 points*) Determine if the data support Mack's assumption. Justify your response based on both the graph and the regression output.

ANSWER:

4. Continued

Mack also observes that "… subsequent development factors $C_{i,k} / C_{i,k-1}$ and $C_{i,k+1} / C_{i,k}$ are not correlated." He proposes a hypothesis test to determine if such pairs of ratios are correlated.

(c) (*2 points*) Describe this test, providing a verbal description, not formulas.

ANSWER:

(d) (*0.5 points*) Describe how the sum of squared errors (SSE) is calculated as presented in Venter.

ANSWER:

(e) (*0.5 points*) Explain why the number of parameters must be taken into account when ranking the accuracy of models.

ANSWER:

(f) (*0.5 points*) Determine the values of *n* and *p* for the fitted chain ladder model.

ANSWER:

Venter suggests three adjustments to SSE to account for the values of *n* and *p*.

(g) (*0.5 points*) State the formula for one of the adjustments.

ANSWER:

5.

Provide the response for this question in the Excel spreadsheet.

(*4 points*) A reinsurer is renewing two property catastrophe treaties, P and Q. The reinsurer uses the Marginal Variance method for allocating risk loads. Output from a hurricane catastrophe model shows that there are five possible loss scenarios.

You are provided with the following:

Scenario	Probability	Loss to Treaty P	Loss to Treaty Q
V	0.85	0	0
W	0.08	50,000	100,000
X	0.04	0	150,000
Y	0.02	100,000	0
Z	0.01	200,000	220,000

The reinsurer uses a risk load multiplier based on Kreps' formula with the following:

- Return on marginal surplus is 20%
- Standard normal distribution multiplier is 2.0537

(a) (*2 points*) Calculate the renewal risk load for each treaty using the Marginal Variance method.

(b) (*1.5 points*) Calculate the renewal risk load for each treaty using the Shapley method.

(c) (*0.5 points*) Describe the relationship between the value of the total risk load for the combined portfolio of P and Q using the Marginal Surplus method versus each of the Marginal Variance and Shapley methods.

.

6.

(*4 points*) You are given the following for X, a random variable representing the amount of a loss:

- $F(x)$ = Probability($X \le x$)
- $G(x) = 1 - F(x)$
- Payment function for a loss is given by:

$$h(X;R,L) = \begin{cases} 0, & 0 < X \le R \\ X - R, & R < X \le (R+L) \\ L, & (R+L) < X \end{cases}$$

- Expected payment for a loss is E[$h(X; R, L)$].
- Number of losses above an amount A is a random variable, N_A.
- Expected number of such losses is E[N_A]

(a) (*2 points*) Show the formula for each of the following using the above notation:

(i) Increased limits factor (ILF) for losses defined as being limited to an amount K, in which the basic limit is an amount B

(ii) Derivative of the ILF from (i) with respect to changes in K

(iii) Expected loss payment for losses defined as being limited to an amount K in which all losses increase by 5%

(iv) Percent reduction of loss frequency for losses defined as being limited to an amount K when the loss is above a specified amount that changes from J to $J + V$, where $V > 0$

ANSWER: Note that you are not required to use *italics* in your response. (i) (ii) (iii) (iv)

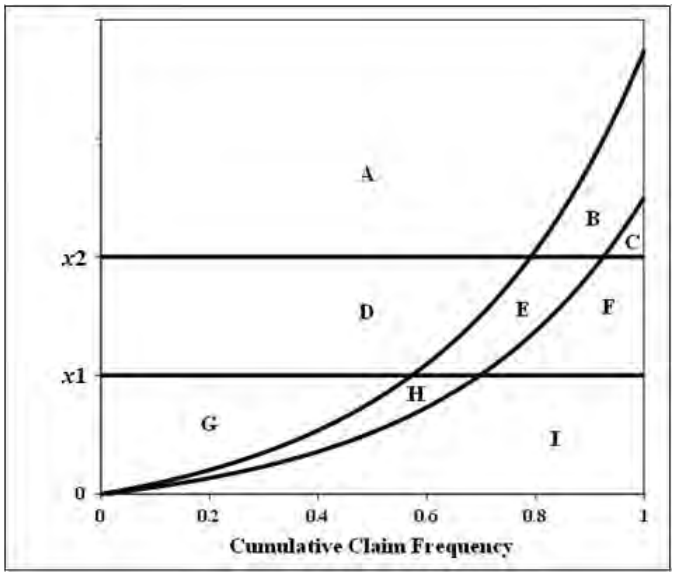
The pure premium from a policy covering losses above a deductible d may be given by $E[N_d] \bullet E[h(X)]$. An assumption must be made for this formula to be true.

(b) (*0.5 points*) State this assumption.

ANSWER:

6. Continued

You are given the following graph of a loss distribution for a coverage with a basic limit of $x1$, both before and after a positive trend factor is applied:



(c) (*1.5 points*) Express each of the following quantities using the labels for the nine areas on the graph:

(i) Increased limit factor for $x2$ before trend

(ii) Increased limit factor for $x2$ after trend

(iii) Trend factor for basic limit losses

(iv) Trend factor for losses limited to $x2$

(v) $x2 - x1$

(vi) Expected ground up losses after trend

ANSWER:
(i)
(ii)
(iii)
(iv)
(v)
(vi)

7.

(*5 points*) Teng and Perkins provide information regarding approaches for estimating the premium asset on retrospectively rated policies as presented by Fitzgibbon and Berry.

Fitzgibbon's approach involves estimating ultimate premium deviation to calculate the retro reserve.

(a) (*1 point*) Define the following as used in Fitzgibbon's approach:

(i) Ultimate premium deviation

(ii) Retro reserve

ANSWER:
(i)

(ii)

(b) (*1 point*) Describe the method used by Fitzgibbon to estimate the ultimate premium deviation.

ANSWER:

(c) (*1 point*) Describe Berry's approach to estimate the retro reserve.

ANSWER:

Teng and Perkins developed their approach because they believed there was an issue with the approaches presented by Fitzgibbon and Berry.

(d) (*0.5 points*) Describe this issue.

ANSWER:

7. Continued

Teng and Perkins' approach relies on premium development to loss development (PDLD) ratios. They present two methods for estimating PDLD ratios, the formula approach and the empirical approach.

(e) (*0.5 points*) Provide an argument in favor of the empirical approach over the formula approach.

ANSWER:

You are given the following values for calculating the premium asset on retrospectively rated policies in policy year X:

PB-Prior	Premium booked as of the prior retro adjustment
PB-Val	Premium booked as of the valuation date
RL-Prior	Reported losses as of the prior retro adjustment
RL-Val	Reported losses as of the valuation date
ULT	Ultimate losses estimated as of the valuation date
PDLD	Applicable PDLD ratio as of the valuation date
CPDLD	Applicable cumulative PDLD ratio as of the valuation date

(f) (*1 point*) State the formula from Teng and Perkins for the premium asset for policy year X as of the valuation date, using the notation above.

ANSWER:

8.

Provide the response for this question in the Excel spreadsheet.

(*4 points*) You are calculating a risk margin for an insurance company using the approach as set out in "A Framework for Assessing Risk Margins" by Marshall, et al. The first step in this calculation is to prepare the claims portfolio for analysis.

(a) (*0.5 points*) Explain why it may not be preferable to split the claims portfolio for risk margin analysis at the same granular level as used for central estimate valuation purposes.

Stochastic modelling techniques were used to obtain the following information:

	Central Estimate (in millions)		**Independent Risk Standard Deviation (in millions)**	
Line of Business	**Outstanding Claims**	**Premium Liabilities**	**Outstanding Claims**	**Premium liabilities**
Liability	4,000	1,200	280	180
Home	800	2,000	24	90

(b) (*1 point*) Calculate the Total Independent Risk Coefficient of Variation (CoV) for both lines combined.

You are given the following additional information:

	Internal Systemic Risk CoV	
Line of Business	**Outstanding Claims (OSC)**	**Premium Liabilities (PL)**
Liability	8.0%	9.5%
Home	6.0%	5.0%

	Internal Systemic Risk Correlation Matrix			
	Liability OSC	**Liability PL**	**Home OSC**	**Home PL**
Liability OSC	100%	50%	25%	25%
Liability PL	50%	100%	0%	25%
Home OSC	25%	0%	100%	75%
Home PL	25%	25%	75%	100%

8. Continued

(c) (*1.5 points*) Calculate the total internal systemic risk CoV for both lines combined.

Marshall, et al. identify several additional analyses that may be conducted to give an actuary further comfort regarding this approach for calculating risk margins.

(d) (*1 point*) Describe two of the additional analyses identified.

9.

(*4 points*) If a reinsurance contract transfers "substantially all of the insurance risk" of the primary contract or risk transfer is "reasonably self-evident," the contract is viewed as having sufficient risk transfer to be accounted for as reinsurance.

(a) (*1 point*) Describe what must be shown for a contract to be identified as transferring "substantially all of the insurance risk" of the primary contract.

ANSWER:

(b) (*1 point*) Identify two types of reinsurance contracts in which risk transfer is "reasonably self-evident."

ANSWER:

Ruhm and Brehm present one rule and several risk metrics for determining risk transfer.

(c) (*0.5 points*) Describe the rule.

ANSWER:

(d) (*1 point*) Describe two of the risk metrics.

ANSWER:

(e) (*0.5 points*) Identify a type of reinsurance that doesn't meet the rule from part (c) but clearly transfers significant insurance risk.

ANSWER:

10.

Provide the response for this question in the Excel spreadsheet.

(*5 points*) You are given the following :

Accident Year (AY)	Reported Claims as of December 31, 2024 (000)		
	at Total Limits	at 1,000,000 Limits	at 500,000 Limits
2018	6,007	5,946	4,883
2019	5,728	5,728	3,748
2020	6,139	6,139	5,109
2021	5,572	5,556	4,294
2022	6,417	6,412	5,301
2023	5,634	5,586	4,045
2024	5,063	4,880	2,911

Development Factors for Reported Claims at Total Limits						
Selected Age-to-Age	12-24	24-36	36-48	48-60	60-72	72-84
	1.214	1.083	1.030	1.016	1.010	1.005

Selected Severity Relativity (R_t)							
	12-24	24-36	36-48	48-60	60-72	72-84	84-Ult
500,000 to Unlimited	0.735	0.698	0.650	0.637	0.628	0.624	0.621
1,000,000 to Unlimited	0.943	0.915	0.906	0.892	0.880	0.874	0.872

- There is no development beyond 84 months.
- Claims at total limits are equal to unlimited claims.

(a) (*1.75 points*) Calculate the total IBNR as of December 31, 2024 for the layer 500,000 excess of 500,000, using Siewert's formula.

(b) (*1.25 points*) Calculate the total IBNR as of December 31, 2024 for losses excess of 1,000,000, using Siewert's formula.

(c) (*1 point*) Provide one advantage and one disadvantage of estimating development using the theoretical approach.

10. Continued

You are given the following additional information:

- The increased limit factor (ILF) selected for total limits relative to 1,000,000 limits for an annual policy effective January 1, 2025 is 1.082.
- The annual trend for claims at 1,000,000 limits is 4%.
- The selected IBNR at 1,000,000 limits for AY 2024 is 1,320,000.

(d) (*1 point*) Calculate the ultimate losses for AY 2024 as of December 31, 2024 for losses excess of 1,000,000, using the ILF method.

11.

(*5 points*)

(a) (*1.5 points*) Compare claims-made coverages to occurrence coverages for the following features:

(i) Investment income earned on insurance funds

(ii) Cost in an inflationary environment affecting both frequency and severity

(iii) Pricing accuracy when there are sudden unpredictable changes in trend

ANSWER:
(i)

(ii)

(iii)

A coverage gap may occur for insureds that purchase claims-made coverage.

(b) (*1.5 points*) Provide two scenarios that show how this coverage gap can occur.

ANSWER:

(c) (*1.5 points*) Describe the following:

(i) Step factor

(ii) Tail policy

(iii) Tail factor

ANSWER:
(i)

(ii)

(iii)

11. Continued

(d) (*0.5 points*) Describe the risk of reserve inadequacy for claims-made policies relative to occurrence policies.

ANSWER:

12.

Provide the response for this question in the Excel spreadsheet.

(*5 points*) You are given the following loss data for an insured's occurrence policy effective for calendar year 2024:

Claim Number	Loss Date	Loss Amount Mechanical Breakdown (MB)	Loss Amount Business Interruption (BI)	Loss Amount Total
C01	Feb 24, 2024	18,730	25,000	123,730
	Feb 25, 2024	0	40,000	
	Feb 26, 2024	0	40,000	
C02	Apr 15, 2024	8,330	10,000	18,330
C03	Nov 4, 2024	15,315	20,250	75,565
	Nov 5, 2024	0	40,000	

The policy terms include an insured amount of 120,000 and a per claim limit of 120,000. The claim limit applies after the deductible.

(a) (*4.5 points*) Calculate the amount the insurer must pay for each claim using each of the following deductible terms:

(i) Split (MB/BI) Straight 4,000 / 8000

(ii) Disappearing 15,000 to 50,000

(iii) Franchise 20,000

(iv) Split (MB/BI) Franchise 3,000 / Time 1-day

(v) Aggregate 130,000

(vi) Percentage 4%

(b) (*0.5 points*) Compare the insurer’s treatment of a policy deductible for first-party coverages versus third-party coverages.

13.

Provide the response for this question in the Excel spreadsheet.

(*5 points*) You are using a collective risk model to model catastrophe risks.

The distribution of the number of catastrophe losses is:

Number of Losses	Probability
0	0.42
1	0.25
2	0.18
3	0.10
4	0.05

The expected loss size distribution is:

Loss Size (billions)	Probability
1	0.45
2	0.30
3	0.19
4	0.06

Loss sizes are independent of one another and independent of the number of losses.

(a) (*2 points*) Demonstrate that the mean and coefficient of variation of aggregate losses are 2.065 billion and 1.179 billion, respectively.

You decide to approximate aggregate losses with a lognormal distribution.

(b) (*1.5 points*) Demonstrate that the method of moments estimates are $\mu = 0.289$ and $\sigma^2 = 0.872$.

(c) (*1 point*) Calculate the probability of aggregate losses exceeding 4 billion using the lognormal model.

(d) (*0.5 points*) State one advantage and one disadvantage of using a lognormal model.

****END OF EXAMINATION****