SOCIETY OF ACTUARIES

Advanced Topics in General Insurance

Exam GIADV

Date: Friday, May 5, 2023

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) 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. 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 five-digit candidate number in the filename.

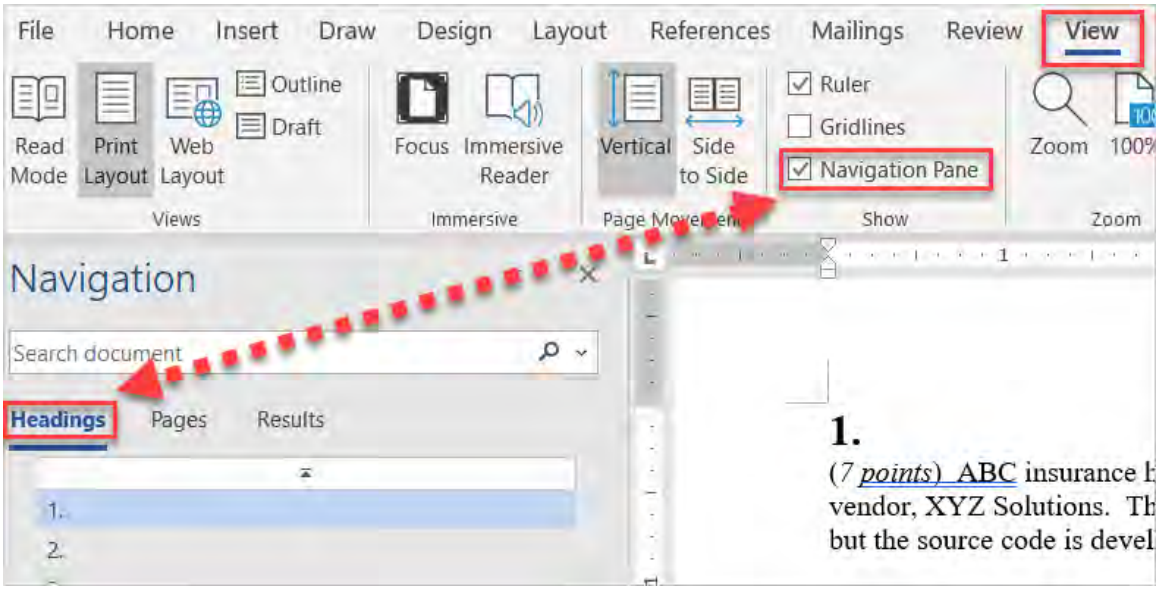
4. The Word and Excel files that contain your answers must be uploaded before the five-minute upload period expires.

475 N. Martingale Road
Schaumburg, IL 60173-2226

Navigation Instructions

Open the Navigation Pane to jump to questions.

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



1.

(*5 points*) Your reinsurance company is evaluating a proposed casualty per occurrence excess treaty covering the layer 3,000,000 excess of 1,000,000. The following information has been provided:

Subject Premium	Underlying Limit	Policy Limit
3,000,000	0	1,000,000
4,000,000	0	2,000,000
5,000,000	1,000,000	3,000,000
2,000,000	1,000,000	2,000,000
6,000,000	0	5,000,000

Policy Limit	Increased Limits Factor
1,000,000	1.00
2,000,000	1.16
3,000,000	1.28
4,000,000	1.38
5,000,000	1.46

The expected loss ratio is 60%.

(a) (*3 points*) Calculate the expected losses in the layer using an exposure rating approach.

Provide the response for this part in the Excel spreadsheet.

You are also evaluating a proportional treaty with a sliding scale commission. You are given the following information:

Loss Ratio	Probability
40%	15%
50%	35%
60%	25%
70%	15%
80%	8%
90%	2%

Sliding Scale	
Loss Ratio	**Commission**
50% or below	30%
50% - 90%	Sliding 0.5:1
90% or above	10%

1. Continued

(b) (*1 point*) Calculate the expected technical ratio (loss ratio plus commission ratio) for the treaty.

Provide the response for this part in the Excel spreadsheet.

(c) (*1 point*) Assess whether the sliding scale commission is balanced.

Provide the response for this part in the Excel spreadsheet.

2.

(*4 points*)

(a) (*1.5 points*) Describe how an insured's risk control activities affect each of the following individual risk rating plans:

(i) Schedule rating

(ii) Prospective experience rating

(iii) Retrospective experience rating

ANSWER:

(b) (*0.5 points*) Explain why insurers use schedule rating.

ANSWER:

The basic formula for the experience modification factor in prospective experience rating is as follows:

$$\frac{AZ + E(1-Z)}{E}$$

Where:

A is for actual claims
E is for expected claims
Z is for credibility

The NCCI "Experience Rating Plan Manual for Workers' Compensation and Employers' Liability Insurance" includes a formula for the experience modification factor that differs from the basic formula.

(c) (*1.5 points*) Describe how the NCCI formula differs from the basic formula.

ANSWER:

2. Continued

Retrospective experience rating is not appropriate for insureds with a small premium size.

(d) (*0.5 points*) Identify two other characteristics of insureds that would make retrospective experience rating inappropriate.

ANSWER:

3.

(*5 points*) You are given the following data extracted from a triangle of cumulative paid losses.

Accident Year	From (months)	To (months)	Increment	Diagonal Age	Accident Year Total
2019	0	12	3,100	48	7,100
2019	12	24	2,400	48	7,100
2019	24	36	1,100	48	7,100
2019	36	48	500	48	7,100
2020	0	12	2,300	36	3,800
2020	12	24	600	36	3,800
2020	24	36	900	36	3,800
2021	0	12	3,200	24	6,000
2021	12	24	2,800	24	6,000
2022	0	12	3,600	12	3,600

You are also given the following onlevel premiums:

Accident Year	Onlevel Premium
2019	10,000
2020	12,000
2021	15,000
2022	18,000

You apply Clark's stochastic reserving model using the Cape Cod method and an exponential distribution with cumulative distribution function $G(x) = 1 - e^{-x/\theta}$ where x is in months.

Clark assumes that the incremental loss emergence follows an overdispersed Poisson distribution.

(a) (*1 point*) State two advantages of using the overdispersed Poisson distribution as opposed to the Poisson distribution.

ANSWER:

Clark also assumes that the incremental losses are independent and identically distributed.

3. Continued

(b) (*0.5 points*) Describe a situation where incremental losses may not be independent.

ANSWER:

(c) (*0.5 points*) Describe a situation where incremental losses may not be identically distributed.

ANSWER:

The maximum likelihood estimate (MLE) of θ is 12.3549.

(d) (*1 point*) Demonstrate that the MLE of *ELR* is 0.5251.

Provide the response for this part in the Excel spreadsheet.

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

Provide the response for this part in the Excel spreadsheet.

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

Provide the response for this part in the Excel spreadsheet.

4.

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

Mack's method of estimating reserve variability is applied to this triangle.

Accident Period	Development Period							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1st Half 2019	2,011	4,747	5,863	8,713	13,512	18,518	20,589	21,443
2nd Half 2019	1,900	6,042	12,150	21,622	34,104	42,257	44,612	
1st Half 2020	2,185	4,436	8,699	13,914	19,905	21,101		
2nd Half 2020	1,957	3,519	6,247	9,799	10,823			
1st Half 2021	2,065	3,863	8,290	10,675				
2nd Half 2021	1,896	4,627	8,442					
1st Half 2022	1,698	5,493						
2nd Half 2022	1,923							
f_k	2.38674	1.82459	1.56908	1.44953	1.21260	1.07283	1.04148	
σ_i^2	654.963	469.913	310.802	537.915	411.856	40.532	3.989	

Accident Period	Reserve	Standard Error
1st Half 2019	0	0
2nd Half 2019	1,850	751
1st Half 2020	2,476	1,200
2nd Half 2020	3,841	2,693
1st Half 2021	10,290	4,862
2nd Half 2021	17,572	6,542
1st Half 2022	25,392	9,065
2nd Half 2022	23,883	10,569

One of the statistical assumptions underlying the chain ladder model is that the accumulated total claim amounts from different accident periods are independent.

(a) (*1 point*) State whether or not this implies that the errors in reserve estimates for different accident periods are independent. Justify your answer.

ANSWER:

(b) (*1 point*) State the other two statistical assumptions underlying the chain ladder model.

ANSWER:

4. Continued

(c) (*2 points*) Demonstrate that the standard error for the first half of 2021 has been correctly calculated.

Provide the response for this part in the Excel spreadsheet.

(d) (*2 points*) Calculate the standard error for the full year of 2021.

Provide the response for this part in the Excel spreadsheet.

(e) (*1 point*) Describe Mack's nonparametric test for correlations between development factors.

Provide the response for this part in the Excel spreadsheet.

(f) (*0.5 points*) Describe the adjustment that Venter suggests to correct for correlation between adjacent development factors.

Provide the response for this part in the Excel spreadsheet.

(g) (*1 point*) Describe Mack's nonparametric test for calendar year effects.

Provide the response for this part in the Excel spreadsheet.

(h) (*0.5 points*) Describe a model that Venter suggests could account for calendar year effects.

Provide the response for this part in the Excel spreadsheet.

5.

(*3 points*) JKL Reinsurance Company is planning to write three reinsurance treaties covering hurricane claims. The output from hurricane catastrophe modeling shows that there are six possible scenarios from writing these reinsurance treaties. You are provided with the following information:

Scenario	Probability	Loss to Treaty P	Loss to Treaty Q	Loss to Treaty R
U	0.80	0	0	0
V	0.08	50,000	100,000	80,000
W	0.06	0	150,000	120,000
X	0.03	100,000	0	175,000
Y	0.02	200,000	220,000	250,000
Z	0.01	0	300,000	0

JKL calculates the risk loads based on variance with a multiplier λ equal to 0.00000025.

(a) (*1.5 points*) Calculate the renewal risk load for each treaty using the Marginal Variance method.

Provide the response for this part in the Excel spreadsheet.

(b) (*1 point*) Calculate the renewal risk load for each treaty using the Shapley method.

Provide the response for this part in the Excel spreadsheet.

JKL is considering using the Covariance Share method to calculate the risk loads instead of the Shapley method.

(c) (*0.5 points*) Explain how the risk loads calculated using the Covariance Share method would differ from those using the Shapley method.

Provide the response for this part in the Excel spreadsheet.

6.

(*4 points*) You are working with the following discrete approximation to a continuous loss distribution:

Loss	Prob	Loss	Prob	Loss	Prob	Loss	Prob	Loss	Prob
1,000	0.0822	**21,000**	0.0108	**41,000**	0.0041	**61,000**	0.0022	**81,000**	0.0014
2,000	0.0691	**22,000**	0.0102	**42,000**	0.0040	**62,000**	0.0021	**82,000**	0.0013
3,000	0.0590	**23,000**	0.0095	**43,000**	0.0039	**63,000**	0.0021	**83,000**	0.0013
4,000	0.0510	**24,000**	0.0091	**44,000**	0.0037	**64,000**	0.0020	**84,000**	0.0013
5,000	0.0444	**25,000**	0.0086	**45,000**	0.0036	**65,000**	0.0020	**85,000**	0.0013
6,000	0.0392	**26,000**	0.0081	**46,000**	0.0035	**66,000**	0.0019	**86,000**	0.0012
7,000	0.0348	**27,000**	0.0077	**47,000**	0.0033	**67,000**	0.0019	**87,000**	0.0012
8,000	0.0311	**28,000**	0.0073	**48,000**	0.0033	**68,000**	0.0019	**88,000**	0.0012
9,000	0.0280	**29,000**	0.0069	**49,000**	0.0031	**69,000**	0.0018	**89,000**	0.0012
10,000	0.0253	**30,000**	0.0066	**50,000**	0.0030	**70,000**	0.0017	**90,000**	0.0011
11,000	0.0230	**31,000**	0.0063	**51,000**	0.0030	**71,000**	0.0017	**91,000**	0.0011
12,000	0.0211	**32,000**	0.0061	**52,000**	0.0028	**72,000**	0.0017	**92,000**	0.0011
13,000	0.0193	**33,000**	0.0057	**53,000**	0.0028	**73,000**	0.0016	**93,000**	0.0011
14,000	0.0177	**34,000**	0.0055	**54,000**	0.0027	**74,000**	0.0016	**94,000**	0.0011
15,000	0.0164	**35,000**	0.0053	**55,000**	0.0026	**75,000**	0.0016	**95,000**	0.0010
16,000	0.0152	**36,000**	0.0051	**56,000**	0.0025	**76,000**	0.0015	**96,000**	0.0010
17,000	0.0142	**37,000**	0.0048	**57,000**	0.0025	**77,000**	0.0015	**97,000**	0.0010
18,000	0.0131	**38,000**	0.0047	**58,000**	0.0024	**78,000**	0.0015	**98,000**	0.0010
19,000	0.0123	**39,000**	0.0045	**59,000**	0.0023	**79,000**	0.0014	**99,000**	0.0010
20,000	0.0116	**40,000**	0.0043	**60,000**	0.0023	**80,000**	0.0014	**100,000**	0.0010

The remaining probability is for losses greater than 100,000.

(a) (*1 point*) Calculate the expected payment per loss for a policy with a limit of 50,000 using <u>both</u> the size method and the layer method.

Provide the response for this part in the Excel spreadsheet.

(b) (*1 point*) Calculate the expected payment per loss for the layer from 50,000 to 100,000 using <u>both</u> the size method and the layer method.

Provide the response for this part in the Excel spreadsheet.

After several years, all losses have increased by 25 percent.

(c) (*0.5 points*) Calculate the new expected payment per loss for a policy with a limit of 50,000 using <u>either</u> the size method or the layer method.

Provide the response for this part in the Excel spreadsheet.

6. Continued

(d) (*0.5 points*) Calculate the new expected payment per loss for the layer from 50,000 to 100,000 using either the size method or the layer method.

Provide the response for this part in the Excel spreadsheet.

(e) (*0.5 points*) Calculate the trend factor for the policy with a limit of 50,000 and the trend factor for the layer from 50,000 to 100,000.

Provide the response for this part in the Excel spreadsheet.

(f) (*0.5 points*) Calculate the increased limit factor for 100,000 with a basic limit of 50,000, both before and after trend. Explain any difference.

Provide the response for this part in the Excel spreadsheet.

7.

(*4 points*) The premium asset on retrospectively rated polices may be calculated using either of the following methods:

- Fitzgibbon's method
- PDLD method (developed by Teng and Perkins)

In Fitzgibbon's method, a linear function relates retrospective premium to losses incurred. This can be restated as $Y = A + Bx$ where Y is the retrospective adjustment as a percentage of standard premium.

(a) (*1 point*) Describe what each of A, B, and x represent.

ANSWER:

(b) (*1 point*) Describe how the PDLD method differs from Fitzgibbon's method with respect to the function relating retrospective premium to losses incurred.

ANSWER:

(c) (*0.5 points*) Describe the two methods for calculating PDLD ratios.

ANSWER:

You are given the following information for a company's retrospectively rated policies:

Retro Adjustment Period	Loss Evaluation Point in Months	Percentage of Loss Emerged Since Prior Evaluation	Selected PDLD Ratio
First	18	68.0%	1.710
Second	30	19.5%	0.715
Third	42	9.5%	0.445
Fourth	54	3.0%	0.300

No losses are reported after the fourth retro adjustment.

7. Continued

You have the following amounts from the company's retrospectively rated policies for policy years 2020 and 2021:

Policy Year	Premium Booked as of Year-End 2022	Completed Retro Adjustments as of Year-End 2022	Expected Loss Emergence after Last Completed Retrospective Adjustment	Premium Booked from Prior Retrospective Adjustment
2020	385,800	1	85,500	375,200
2021	371,500	0	320,100	0

(d) (*1.5 points*) Calculate the premium asset on retrospectively rated policies as of December 31, 2022 arising from policy years 2020 and 2021 using the PDLD method.

Provide the response for this part in the Excel spreadsheet.

8.

(*4 points*) In "A Framework for Assessing Risk Margins," Marshall et al. (Marshall) list nine components of their risk margin framework. This includes independent risk analysis, internal systemic risk analysis and external systemic risk analysis.

(a) (*1 point*) Describe two of these components, other than the three listed above.

ANSWER:

Marshall outlines a balanced scorecard approach to analyze internal systemic risk. This approach requires subjective decisions to be made.

(b) (*1 point*) Identify four subjective decisions that are required in this approach.

ANSWER:

You are employing the approach set out in Marshall and are given the following:

Valuation Class	**Proportion of Total Insurance Liabilities**	
	Outstanding Claims	**Premium Liabilities**
Auto	22.5%	30.0%
Liability	40.0%	7.5%

Valuation Class	**Coefficient of Variation (CoV)**				
	Independent Risk		**Internal Systemic Risk**		**External Systemic Risk**
	Outstanding Claims	**Premium Liabilities**	**Outstanding Claims**	**Premium Liabilities**	
Auto	8.00%	5.00%	4.00%	6.00%	3.50%
Liability	6.00%	10.00%	10.00%	12.50%	6.00%
Total	***X***		7.05%	***Y***	***Z***

- Assume the same correlation between the two valuation classes for both outstanding claims and premium liabilities with respect to internal systemic risk.
- The correlation between the two valuation classes for external systemic risk is 0.3.

8. Continued

(c) (*2 points*) Calculate the following:

(i) Total independent risk CoV for both valuation classes combined (***X***)

(ii) Correlation between the valuation classes for outstanding claims for internal systemic risk

(iii) Internal systemic risk CoV for premium liabilities for both valuation classes combined (***Y***)

(iv) Total external systemic risk CoV for both valuation classes combined (***Z***)

Provide the response for this part in the Excel spreadsheet.

9.

(*4 points*) You are given the following information regarding a reinsurance contract:

- It applies to claims incurred in 2023 for all lines of business combined.
- It is an aggregate excess of loss contract for the layer 100 million excess of 150 million.
- Ceded premium is 48 million, paid on January 1, 2023.
- Cedant's loss participation is 65%.
- Reinsurance payments and the cedant's loss participation payment occur on July 1, 2026.

The aggregate distribution of claims incurred in 2023 is estimated as follows:

Probability of Result	Incurred in Millions
55.0%	65.5
12.0%	87.6
7.5%	108.0
5.5%	123.6
5.0%	139.3
2.5%	150.0
2.5%	165.6
2.0%	175.8
2.0%	202.6
1.5%	225.4
1.5%	253.7
1.0%	270.1
1.0%	286.5
0.5%	304.5
0.5%	345.5

- Most of the claims from this business are expected to be paid in 2023 and all will be paid before the end of 2025.
- The annual after-tax investment yield is 4.0% at inception of the reinsurance contract.

(a) (*1 point*) Explain why the risk transfer in this reinsurance contract would <u>not</u> be categorized as "reasonably self-evident" to permit reinsurance accounting.

ANSWER:

9. Continued

(b) (*2.5 points*) Determine whether or not this reinsurance contract transfers sufficient risk to permit reinsurance accounting using the Expected Reinsurer Deficit (ERD) test with a threshold of 1%.

Provide the response for this part in the Excel spreadsheet.

Reinsurance accounting may be applicable even if the risk transfer in this reinsurance contract is not categorized as "reasonably self-evident" and the contract does not meet the conditions for risk transfer from a quantitative test.

(c) (*0.5 points*) Describe when this may apply.

Provide the response for this part in the Excel spreadsheet.

10.

(*4 points*) You are given the following information for estimating claims in excess of 400,000 for a liability line of business:

Accident Year	Reported Claims (000) at Total Limits					
	12	24	36	48	60	72
2017	784	880	938	983	1,006	1,016
2018	1,011	1,164	1,288	1,367	1,380	
2019	1,062	1,233	1,331	1,404		
2020	1,120	1,231	1,328			
2021	1,230	1,400				
2022	1,200					

Accident Year	Reported Claims (000) at 400,000 Limit					
	12	24	36	48	60	72
2017	770	862	917	959	980	989
2018	932	1,002	1,091	1,159	1,168	
2019	862	942	1,008	1,054		
2020	1,100	1,203	1,297			
2021	1,093	1,190				
2022	1,133					

Summary of Severity Relativity (R_t) of 400,000 Limit to Total Limits by maturity age					
12	24	36	48	60	72
0.88	0.84	0.81	0.79	0.79	0.79

There is no development beyond 72 months.

(a) (*2 points*) Calculate the total IBNR for claims excess of 400,000 as of December 31, 2022 using each of the following approaches:

(i) Development factors calculated using a simple average

(ii) Theoretically-derived development factors based on Siewert's formula

Provide the response for this part in the Excel spreadsheet.

(b) (*0.5 points*) Describe two considerations in the calculation of R_t values.

Provide the response for this part in the Excel spreadsheet.

10. Continued

(c) (*1 point*) Explain why alternative methods should be considered based on the results from part (a).

Provide the response for this part in the Excel spreadsheet.

You are assessing the increased limits factors approach as an alternative.

(d) (*0.5 points*) Identify two considerations when applying the increased limits factors approach.

Provide the response for this part in the Excel spreadsheet.

11.

(*4 points*)

(a) (*1.5 points*) Describe the following terms with respect to claims-made insurance:

(i) Step factor

(ii) Tail policy

(iii) Tail factor

ANSWER:

An insurer writes claims-made coverage with a 6-year reporting pattern. The reporting pattern is as follows:

Claims Incurred in an Accident Year are Reported in the Year of	**Percent**
Occurrence	25%
Occurrence + 1	30%
Occurrence + 2	20%
Occurrence + 3	10%
Occurrence + 4	10%
Occurrence + 5	5%

The annual accident year trend is 5%.

(b) (*2.5 points*) Calculate tail factors for a claims-made policy for the following maturities:

(i) First year

(ii) Third year

(iii) Mature

Provide the response for this part in the Excel spreadsheet.

12.

(*5 points*) You are conducting an increased limits analysis for an insurer looking to enter a liability line of business. You are given the following insurance industry aggregated claims data by size of claim:

Indemnity Range (000)		Counts in Interval	Indemnity Severity in Interval	ALAE % of Indemnity
From	To			
0	500	2,881	235,817	20.2%
501	1,000	384	715,448	15.3%
1,001	1,500	124	1,232,765	16.5%
1,501	2,500	77	1,960,198	14.0%
2,501	3,500	22	2,825,640	9.5%
3,501	5,000	41	4,243,226	7.4%

- Data is evaluated as of December 31, 2022 and includes accident years 2018 and 2019 combined.
- The line of business for the industry data is similar to that being looked at by the insurer.
- ALAE is unlimited.

(a) (*1 point*) Describe two issues that should be investigated with respect to the industry data used in this analysis.

ANSWER:

(b) (*2 points*) Calculate the observed increased limits factors (ILFs) for the following indemnity limits, relative to a basic indemnity limit of 1,000,000:

(i) 1,500,000

(ii) 2,500,000

(iii) 3,500,000

(iv) 5,000,000

Provide the response for this part in the Excel spreadsheet.

12. Continued

(c) (*1 point*) Test the consistency of the ILFs calculated in part (b).

Provide the response for this part in the Excel spreadsheet.

(d) (*1 point*) Recommend an ILF for a 2,000,000 indemnity limit. Justify your recommendation.

Provide the response for this part in the Excel spreadsheet.

13.

(*5 points*) XYZ Insurance has reinsurance arrangements applied in the following order:

Reinsurance Treaty	**Description**
Surplus Share	4 lines with 1,000 retained line
Per Risk Excess of Loss	2,000 in excess of 1,000
Catastrophe	6,000 in excess of 4,000

During the year, an earthquake caused the following covered losses for XYZ:

Property	**Insured Value**	**Loss**
A	2,500	1,200
B	10,000	8,000
C	1,000	400
D	4,000	1,600
E	8,000	3,000

(a) (*2 points*) Calculate the total losses recoverable under each treaty.

Provide the response for this part in the Excel spreadsheet.

You are provided with the following information on the catastrophe treaty:

- The annual premium is 600.
- There is a reinstatement provision that is 125% pro-rata as to amount.

(b) (*0.5 points*) Calculate the reinstatement premium for the catastrophe treaty.

Provide the response for this part in the Excel spreadsheet.

13. Continued

A different insurer, ABC Insurance, has a per risk excess of loss reinsurance treaty as follows:

Treaty Limit	6,000
Attachment Point	2,000
Annual Aggregate Deductible (AAD)	10,000

ABC's claims covered by the treaty in order of occurrence are:

Claim Number	Ultimate Claim
1	10,200
2	800
3	4,900
4	7,000
5	6,500

(c) (*2.5 points*) Calculate the amount retained by ABC for each claim.

Provide the response for this part in the Excel spreadsheet.

****END OF EXAMINATION****