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## Exam Content Outline

# Modern Actuarial Statistics I (MAS-I)

## Delivery Format

APPOINTMENT TIME: 4.5 HOURS		
<b>Exam Duration</b>	<b>Scheduled Break</b>	<b>Exam Tutorial, Confidentiality Agreement, End of Exam Survey</b>
<b>4 hours</b>	<b>15 min</b>	<b>15 min</b>

## Exam Item Types

Candidates may see the following item types in the CAS examinations. Candidates should become familiar with these item types. Item type samples are available on the Pearson Vue CAS webpage.

### Multiple Choice

Multiple answer choices are presented after a problem with only one correct answer.

### Multiple Selection

Multiple answer choices are presented after a problem with more than one correct answer.

### Point and Click

An image is presented after a problem where the candidate must identify the correct area of the image by clicking on the correct location in the image.

### Fill in the Blank

One or more blank sections are presented after the problem or within a statement where the candidate must input the correct response(s).

### Matching

Content columns presented after a problem where the candidate must correctly match content from one column to another.



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## Exam Cognitive Level

Each task is tied to a certain type of mental operation or thinking skill, which is called the cognitive level. ACAS and FCAS use four cognitive levels, and every examination item is authored to address both the task and one of the following cognitive levels paired with that task.

### **Remember: 5-10%**

Tests the ability of the candidate to recall or remember knowledge or facts.

### **Understand and Apply: 55-60%**

Measures the candidate's ability to understand and apply ideas and concepts to new situations.

### **Analyze and Evaluate: 35-40%**

Requires the candidate analyze information, combine concepts/ideas, and justify a position resulting from that combination.

### **Create: 0-5%**

Requires the candidate to synthesize conclusions by evaluating the validity of ideas and concepts.



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## Exam Section Details

DOMAINS	DOMAIN WEIGHT
<b>A. Probability Models (Stochastic Processes and Survival Models)</b>	20-30%
<b>B. Statistics</b>	20-30%
<b>C. Extended Linear Models</b>	45-55%

### A. Probability Models (Stochastic Processes and Survival Models)

Candidates should be able to solve problems using stochastic processes and determine the probabilities and distributions associated with these processes.

TASKS
1. Model claim frequencies using Poisson processes
2. Calculate expected values, variances, and probabilities for any Poisson process
3. Calculate limited expected value
4. Perform survival model and hazard rate calculations
5. Perform joint life calculations
6. Calculate simple whole life or annuity problems
Readings: <ul style="list-style-type: none"><li>- Daniel</li><li>- Ross</li><li>- Struppeck</li></ul>



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## B. Statistics

Candidates should be able to apply the concepts typically covered in the 2<sup>nd</sup> semester of a two-semester undergraduate sequence in Probability and Statistics.

TASKS
1. Estimate the mean and variance given a sample
2. Estimate a sufficient statistic for a distribution
3. Test statistical hypotheses, including Type I and Type II errors
4. Test means and variances using critical values from a sampling distribution
5. Model insurance claim frequency and severity
6. Model insurance claims in aggregate
7. Calculate order statistics of a sample
8. Perform point estimation of statistical parameters using maximum likelihood estimation (MLE) applying criteria to estimates such as consistency, unbiasedness, sufficiency, efficiency, minimum variance, mean square error (e.g., accounting for censoring and truncation in the data)
9. Adjust calculations for the effect of missing data values, including censoring and truncation
Readings: There are many good introductory statistics textbooks that do an excellent job of covering the material on Section B. In the interest of clarity for the candidates, though, we have selected two. - Hogg, McKean, and Craig - Tse



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## C. Extended Linear Models

Candidates should be able to solve problems using extended linear models and determine when these models are appropriate to use.

<b>TASKS</b>
1. Select the appropriate model for an extended linear model
2. Select the appropriate model structure for an extended linear model given the behavior of the data set to be modeled (e.g., appropriate link function and distribution for the dependent variable for GLM)
3. Evaluate models developed using an extended linear model approach
4. Interpret the extended linear model output from statistical software, such as parameter estimate tables and ANOVA tables
5. Distinguish among categorical, ordinal, and continuous predictors and their interactions, and how these relate to their usage in an extended linear model
6. Understand and apply control and offset variables in GLMs
7. Understand and calculate AIC, BIC, deviance, and R-squared
8. Analyze model diagnostic plots (e.g., residual, marginal model, QQ, and added variable plots) to assess quality of fit
9. Interpret exploratory data analysis plots for various data types (e.g., box, univariate, histograms)
Readings: <ul style="list-style-type: none"><li>- Dobson and Barnett</li><li>- Hogg, McKean, and Craig</li><li>- James et al.</li><li>- Larsen</li></ul>



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## Complete Text References for Exam MAS-I

Text references are alphabetized by the citation column.

Citation	Abbreviation	Domains/ Tasks	Source
Daniel, J.W., " <a href="#">Poisson processes (and mixture distributions)</a> ," CAS Study Note, June 2008. Note: <a href="#">Practice Problems</a> as noted in the paper's Foreword are available on the CAS website.	Daniel	A1-5	<b>OP</b>
Dobson, A., and Barnett, A., <i>An Introduction to Generalized Linear Models</i> , 4 <sup>th</sup> edition, Chapman and Hall/CRC Press, 2018. - Chapters 1-9, excluding 6.3.3, 6.7, 6.8, & 7.9	Dobson & Barnett	C1-C9	<b>B</b>
Hogg, R.V., McKean, J.W., and Craig, A.T., <i>Introduction to Mathematical Statistics</i> , 8 <sup>th</sup> edition, Prentice Hall, 2018. - Domain B: Sections 1.7, 2.7, 2.8, 3.7, 4.1, 4.4, 4.5, 4.6, 4.7, 5.1, 6.1, 6.2, 6.3, 6.4, 6.5, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 8.1, 8.2, 8.3 - Domain C: 4.4, 6.3, 6.5, 7.5, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6	Hogg, McKean, and Craig	B1-B8, C1-C9	<b>B</b>
James, G., et al., <a href="#">An Introduction to Statistical Learning, with Application in R, 2<sup>nd</sup> edition</a> , Springer, 2021. - Chapters 1, 2 (excluding Section 2.2.3), 3 (Sections 3.1 through 3.3, and 3.6 labs on Sections 3.1 through 3.3), 4 (Sections 4.1 through 4.4; the Linear Discrimination Analysis portion of Section 4.4 will not be tested), 5, 6, and 7	James et al.	C1-C9	<b>OP</b>
Larsen, M., " <a href="#">Generalized Linear Models</a> ," CAS Study Note, December 2015, revised June 2016.	Larsen	C1-C9	<b>OP</b>
Ross, S. M., <i>Introduction to Probability Models</i> , 11 <sup>th</sup> edition or 12 <sup>th</sup> edition, Academic Press (an imprint of Elsevier, Inc.), 2014/ 2019. - Sections 4.1-4.8, 5.2.1-5.2.4, 5.3, 5.4.1, 5.4.2, 9.1-9.6, 11.1, 11.2.1, and 11.2.2	Ross	A1-A6	<b>B</b>
Struppeck, T., " <a href="#">Life Contingencies</a> ," CAS Study Note, October 2014, revised September 2015.	Struppeck	A5-6	<b>OP</b>
Tse, Y., <i>Nonlife Actuarial Models, Theory Methods and Evaluation</i> , Cambridge University Press, 2009. - Sections 1.1, 2.2, 2.3, 2.4, 2.5, 10.1, 10.2, 11.1, 12.1, 12.3, 13.2	Tse	B1-B4, B7-9	<b>B</b>



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## Supplemental Study Materials

*The readings cited above are the expected readings that candidates should incorporate into their study plans and represent the minimum study needed for this exam. The expected readings are also exclusively used by CAS Subject Matter Experts who create the examination content.*

*In addition to the expected readings, candidates may consider the recommended information and readings below to incorporate into their study plans. The recommended materials will provide candidates with helpful knowledge to perform the exam tasks.*

## Parameter and Diagnostic Tables

Exam questions may contain parameter tables and diagnostic tables or plots of the type shown in the texts. Candidates should understand how to interpret these tables. Candidates who become familiar with a statistical language capable of generating this type of output, such as R, will have an easier time understanding and applying the concepts covered in the exam material. In particular, candidates that work the lab exercises at the end of the chapters in the James, Gareth, et al. textbook will have a better grasp of the material than that obtained by simply reading the textbook. However, for exam questions, candidates will not be asked to write or interpret R code.

## GLM Problems

Candidates are encouraged to seek out examples of GLM problems to enhance their understanding of GLM concepts. Candidates will not be tested on concepts that are outside of the scope of the required reading that may appear in those examples. The examples are furnished so that candidates might reinforce concepts covered in the Dobson and Barnett textbook.



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## Additional Problems and Examples, Section B and C

### Domain B

For those candidates who would like to work additional problems or see additional examples to illustrate the concepts in Section B, a couple of sources are listed below that are from the Schaum's Outline series. We are not expanding the range of material covered and only mention these additional sources as a study aid.

- Schiller, Spiegel, and Srinivasan: Chapters 4-9
- Spiegel and Stephens: Chapters 8-12

### Domain C

For those candidates who would like to work additional problems or see additional examples to illustrate the concepts in Section C, a couple of sources are listed below that are from the Schaum's Outline series. We are not expanding the range of material covered and only mention these additional sources as a study aid.

Citation	Abbreviation	Domains/ Tasks	Source
Salvatore, D., and Reagle, D., <i>Schaum's Outline of Statistics and Econometrics</i> , McGraw-Hill, 2 <sup>nd</sup> edition, paperback, January 27, 2011, Chapters 6-9.	Salvatore	C/1-4	<b>BO</b>
Schiller, J., Spiegel, M., and Srinivasan, R., <i>Schaum's Outlines of Probability and Statistics: 897 Solved Problems + 20 Videos</i> , McGraw-Hill, 4th edition, Chapters 4-9.	Schiller	B/1-3 C/1-4	<b>BO</b>
Spiegel, M., and Stephens, L., <i>Schaum's Outline of Statistics</i> , McGraw-Hill, 5 <sup>th</sup> edition, Chapters 8-13 and 16.	Spiegel	B/1-3, C/1-4	<b>BO</b>

## Source Key

<b>B</b>	Book – may be purchased from the publisher or bookstore.
<b>BO</b>	Book (Optional) – may be purchased from the publisher or bookstore.
<b>DSK</b>	Material included in the 2023 Digital Study Kit.
<b>OP</b>	All text references marked as Online Publications will be available by clicking the hyperlink within the syllabus.
<b>SK</b>	Material included in the 2023 Study Kit.
<b>SKU</b>	Material included in both the 2023 CAS Study Kit and the 2023 Update to the 2022 Study Kit.

Version: MASI\_CO\_2024\_F v03 2024\_06\_26.docx