Construction and Evaluation of Actuarial Models Exam

The Construction and Evaluation of Actuarial Models exam is called Exam C by the SOA and Exam 4 by the CAS. This three-and-a-half hour exam consists of 35 multiple-choice questions. Also, a preview of the CBT layout of the Exam C/4 tables in HTML is available online since the tables have been divided into five sections for viewing purposes.

The examination is jointly sponsored and administered by the SOA, CAS, and the Canadian Institute of Actuaries (CIA). The examination is also jointly sponsored by the American Academy of Actuaries (AAA) and the Conference of Consulting Actuaries (CCA).

The Construction and Evaluation of Actuarial Models Exam is administered as a computer-based test. For additional details, please refer to Exam Rules. The syllabus for this examination provides an introduction to modeling and covers important actuarial methods that are useful in modeling. A thorough knowledge of calculus, probability, and mathematical statistics is assumed.

The candidate will be introduced to useful frequency and severity models beyond those covered in Exam M. The candidate will be required to understand the steps involved in the modeling process and how to carry out these steps in solving business problems. The candidate should be able to: 1) analyze data from an application in a business context; 2) determine a suitable model including parameter values; and 3) provide measures of confidence for decisions based upon the model. The candidate will be introduced to a variety of tools for the calibration and evaluation of the models.

A variety of tables is available below for the candidate and will be provided to the candidate at the examination. These include values for the standard normal distribution, chi-square distribution, and abridged inventories of discrete and continuous probability distributions. Candidates will not be allowed to bring copies of the tables into the examination room.

Check the Updates section on this exam's home page for any changes to the exam or syllabus.

The ranges of weights shown are intended to apply to the large majority of exams administered. On occasion, the weights of topics on an individual exam may fall outside the published range. Candidates should also recognize that some questions may cover multiple learning outcomes.

Each multiple-choice problem includes five answer choices identified by the letters A, B, C, D, and E, only one of which is correct. Candidates must indicate responses to each question on the computer.

As part of the computer-based testing process, a few pilot questions will be randomly placed in the exam (paper and pencil and computer-based forms). These pilot questions are included to
judge their effectiveness for future exams, but they will NOT be used in the scoring of this exam. All other questions will be considered in the scoring. All unanswered questions are scored incorrect. Therefore, candidates should answer every question on the exam. There is no set requirement for the distribution of correct answers for the SOA/CAS/CIA multiple-choice preliminary examinations. It is possible that a particular answer choice could appear many times on an examination or not at all. Candidates are advised to answer each question to the best of their ability, independently from how they have answered other questions on the examination.

Since the CBT exam will be offered over a period of a few days, each candidate will receive a test form composed of questions selected from a pool of questions. Statistical scaling methods are used to ensure within reasonable and practical limits that, during the same testing period of a few days, all forms of the test are comparable in content and passing criteria. The methodology that has been adopted is used by many credentialing programs that give multiple forms of an exam.

**LEARNING OUTCOMES**

The candidate is expected to be familiar with survival, severity, frequency and aggregate models, and use statistical methods to estimate parameters of such models given sample data. The candidate is further expected to identify steps in the modeling process, understand the underlying assumptions implicit in each family of models, recognize which assumptions are applicable in a given business application, and appropriately adjust the models for impact of insurance coverage modifications.

Specifically, the candidate is expected to be able to perform the tasks listed below: Sections A–E have a combined weight of 15-20%

A. Severity Models
   1. Calculate the basic distributional quantities:
      a) moments
      b) Percentiles
      c) Generating functions
   2. Describe how changes in parameters affect the distribution.
   3. Recognize classes of distributions and their relationships.
   4. Apply the following techniques for creating new families of distributions:
      a) Multiplication by a constant
      b) Raising to a power
      c) Exponentiation,
      d) Mixing
   5. Identify the applications in which each distribution is used and reasons why.
   6. Apply the distribution to an application, given the parameters.
7. Calculate various measures of tail weight and interpret the results to compare the tail weights.

B. Frequency Models
   For the Poisson, Mixed Poisson, Binomial, Negative Binomial, Geometric distribution and mixtures thereof:
   1. Describe how changes in parameters affect the distribution,
   2. Calculate moments,
   3. Identify the applications for which each distribution is used and reasons why,
   4. Apply the distribution to an application given the parameters.
   5. Apply the zero-truncated or zero-modified distribution to an application given the parameters.

C. Aggregate Models
   2. Evaluate compound models for aggregate claims.
   3. Compute aggregate claims distributions.

D. For severity, frequency and aggregate models
   1. Evaluate the impacts of coverage modifications:
      a) Deductibles
      b) Limits
      c) Coinsurance
   2. Calculate Loss Elimination Ratios.
   3. Evaluate effects of inflation on losses.

E. Risk Measures
   1. Calculate VaR, and TVaR and explain their use and limitations.

F. Construction of Empirical Models (20-25%)
   1. Estimate failure time and loss distributions using:
      a) Kaplan-Meier estimator, including approximations for large data sets
      b) Nelson-Åalen estimator
      c) Kernel density estimators
   2. Estimate the variance of estimators and confidence intervals for failure time and loss distributions.
   3. Apply the following concepts in estimating failure time and loss distribution:
      a) Unbiasedness
      b) Consistency
      c) Mean squared error

G. Construction and Selection of Parametric Models (25-30%)
   1. Estimate the parameters of failure time and loss distributions using:
      a) Maximum likelihood
b) Method of moments
c) Percentile matching
d) Bayesian procedures

2. Estimate the parameters of failure time and loss distributions with censored and/or truncated data using maximum likelihood.

3. Estimate the variance of estimators and the confidence intervals for the parameters and functions of parameters of failure time and loss distributions.

4. Apply the following concepts in estimating failure time and loss distributions:
   a) Unbiasedness
   b) Asymptotic unbiasedness
   c) Consistency
   d) Mean squared error
   e) Uniform minimum variance estimator

5. Determine the acceptability of a fitted model and/or compare models using:
   a) Graphical procedures
   b) Kolmogorov-Smirnov test
   c) Anderson-Darling test
   d) Chi-square goodness-of-fit test
   e) Likelihood ratio test
   f) Schwarz Bayesian Criterion

H. Credibility (20-25%)
1. Apply limited fluctuation (classical) credibility including criteria for both full and partial credibility.
2. Perform Bayesian analysis using both discrete and continuous models.
3. Apply Bühlmann and Bühlmann-Straub models and understand the relationship of these to the Bayesian model.
4. Apply conjugate priors in Bayesian analysis and in particular the Poisson-gamma model.
5. Apply empirical Bayesian methods in the nonparametric and semiparametric cases.

I. Simulation (5-10%)
1. Simulate both discrete and continuous random variables using the inversion method.
2. Estimate the number of simulations needed to obtain an estimate with a given error and a given degree of confidence.
3. Use simulation to determine the p-value for a hypothesis test.
4. Use the bootstrap method to estimate the mean squared error of an estimator.
5. Apply simulation methods within the context of actuarial models.

Reading Selections for learning outcomes A through G and I:

Texts*
   Chapter 3
Chapter 4
Chapter 5, Sections 5.1–5.4 only
Chapter 6, Sections 6.1–6.5 and 6.7
Chapter 8
Chapter 9, Sections 9.1–9.7 (excluding 9.6.1 and examples 9.9 and 9.11), Sections 9.11.1–9.11.2
Chapter 12
Chapter 13
Chapter 14
Chapter 15, Sections 15.1–15.6.4, 15.6.6 only
Chapter 16
Chapter 21, Sections 21.1–21.2 (excluding 21.2.4)

Reading Options for learning outcome H (Credibility) will be:

Option A
  Chapter 20, Sections 20.2, 20.3 (excluding 20.3.8), 20.4 (excluding 20.4.3)

Option B
  Chapter 8, Section 1 (background only) Sections 2–5
• *Topics in Credibility* by Dean, C.G.

Option C
• *Introduction to Credibility Theory* (Fourth Edition), 2010, Herzog, T.N.
  Chapter 1-3 (background only)
  Chapters 4–8
  Chapter 9 (background only)

*Any textbook errata are included below.*

Other Resources
*Tables for Exam C/Exam 4*

*Preview of the CBT layout of the Exam C/4 tables in HTML*

*Loss Models Errata Third Edition*

All released exam papers since 2000, can be found at:
*Past Exam Questions and Solutions*
Exam C/4 Sample Questions and Solutions