The syllabus for this exam is defined in the form of learning objectives that set forth, usually in broad terms, what the candidate should be able to do in actual practice.

Please check the “Syllabus Updates” section of the CAS Web Site for any changes to the Syllabus. The options for obtaining credit for this exam are listed below and in Examination Rules, C. Grades and Accreditation, Waivers of Examinations section of the Syllabus.

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 3F. 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.

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.
A. Severity Models

LEARNING OBJECTIVES

1. Calculate the basic distributional quantities:
   • Moments
   • Percentiles
   • 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:
   • Multiplication by a constant
   • Raising to a power
   • Exponentiation
   • 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

LEARNING OBJECTIVES

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

C. Aggregate Models

LEARNING OBJECTIVES

2. Evaluate compound models for aggregate claims.
3. Compute aggregate claims distributions.
D. For Severity, Frequency and Aggregate Models

LEARNING OBJECTIVES
1. Evaluate the impacts of coverage modifications:
   • Deductibles
   • Limits
   • Coinsurance
2. Calculate Loss Elimination Ratios.
3. Evaluate effects of inflation on losses.

E. Risk Measures

LEARNING OBJECTIVES
1. Calculate VaR, and TVaR and explain their use and limitations.

F. Construction of Empirical Models

LEARNING OBJECTIVES
1. Estimate failure time and loss distributions using:
   • Kaplan-Meier estimator, including approximations for large data sets
   • Nelson-Åalen estimator
   • 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:
   • Unbiasedness
   • Consistency
   • Mean squared error

G. Construction and Selection of Parametric Models

LEARNING OBJECTIVES
1. Estimate the parameters of failure time and loss distributions using:
   • Maximum likelihood
   • Method of moments
   • Percentile matching
   • Bayesian procedures
2. Estimate the parameters of failure time and loss distributions with censored and/or truncated data using maximum likelihood.
LEARNING OBJECTIVES

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:
   • Unbiasedness
   • Asymptotic unbiasedness
   • Consistency
   • Mean squared error
   • Uniform minimum variance estimator

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

H. Credibility

LEARNING OBJECTIVES

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

LEARNING OBJECTIVES

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.
Options for Obtaining Exam 4 Credit

The CAS will grant credit for Exam 4 to those who have successfully completed one of the following examinations:

<table>
<thead>
<tr>
<th>Organization</th>
<th>Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuarial Society of South Africa</td>
<td>A202, Models, and A204, Statistical Methods**</td>
</tr>
<tr>
<td>Actuaries Institute (Australia)</td>
<td>CT4, Models, and CT6, Statistical Methods*</td>
</tr>
<tr>
<td>Canadian Institute of Actuaries</td>
<td>University Accreditation Program credit for Construction and Evaluation of</td>
</tr>
<tr>
<td></td>
<td>Actuarial Models</td>
</tr>
<tr>
<td>Institute of Actuaries of India</td>
<td>CT4, Models, and CT6, Statistical Methods*</td>
</tr>
<tr>
<td>Institute and Faculty of Actuaries</td>
<td>CT4, Models, and CT6, Statistical Methods*</td>
</tr>
<tr>
<td>(U.K.)</td>
<td>C, Construction and Evaluation of Actuarial Models Exam</td>
</tr>
</tbody>
</table>

*CT4 & CT6, together, will provide credit for CAS Exams ST and 4 & Validation by Education Experience for Applied Statistical Methods.

**A202 & A204, together, will provide credit for CAS Exams ST and 4 & Validation by Education Experience for Applied Statistical Methods.

Candidates should review carefully the Transition Rules for Exam S approved by the CAS Board of Directors. These rules can be located on the Transition Rules page of the CAS website.

For credit granted through the University Accreditation Program, the list of candidates granted waivers by the CIA is provided to the CAS following the end of a semester. The CAS automatically updates its records. No further action is required of candidates.

To obtain credit otherwise, candidates should follow the procedures outlined on the Waivers of Examination page of the CAS website.