

CASUALTY ACTUARIAL SOCIETY

**Report of the
Design Task Force on
Exams 3 and 4**

28 MAY 2002

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Executive Summary

The Task Force focused on core concepts and materials for Exams 3 and 4. Overall, the Task Force concluded that Exams 3 and 4 meet the needs of casualty actuarial candidates and do not need major changes. The Task Force recommends that some material be removed and that one topic be added.

Exam 3

The coverage of life contingencies should be reduced to approximately the level of old CAS Part 4A. An introductory treatment of pension mathematics should be included with contingent payment models. Stochastic process models should be deleted. Ruin models should be treated in less depth. Suggestions about specific learning objectives and readings reflect these recommendations. If the proposed change to life contingencies material is the only obstacle to jointly administering these exams with the Society of Actuaries, the level of coverage of life contingencies material is not sufficient to warrant separate administration of the exams.

Exam 4

The topics are appropriate. Recommendations are made about specific readings to strengthen the presentation.

Examination Construction

Generally the Task Force believes that the level at which the learning objectives are tested is appropriate. The questions are not too theoretical. Both exams should continue to be tested in four hours. The Examination Committee should consider using essay questions.

For Exam 3, the exam blueprint should be revised so that life contingencies represents 1.5 to 2 hours of the four-hour exam. To minimize memorization, the Syllabus and Examination Committees should consider providing formulas with the exam for the sections on Regression, Forecasting and Time Series and Contingent Payment Models.

Implementation

The Task Force recommends that the suggested deletions be implemented no sooner than the Spring 2003 exam session and that other recommendations be implemented as soon as practical thereafter.

The Charge and Overview

The Charge

The CAS Board of Directors believes that Exams 3 and 4 do not adequately meet the needs of CAS candidates. At its 11 November 2001 meeting, the Board created this task force and charged it with designing and preparing Exams 3 and 4 that are appropriate for casualty actuaries. The proposed exams may be given jointly with the SOA, if the SOA wishes to do so. Otherwise the CAS will administer the exams separately.

The Board developed an action plan that included the following components:

- **Task Force Staffing**

Nancy Braithwaite was asked to chair the committee. Gary Dean was appointed Board liaison to the task force. Ms. Braithwaite was asked to recruit other members from the general membership, current members of other Admissions Committees, academics, the Student Liaison Committee, and The Chauncey Group. The Task Force reported to Vice President-Admissions Mary Frances Miller on a day-to-day basis but is responsible to the Board.

- **Examination Construction**

The Board asked the Task Force to ask The Chauncey Group to provide advice for changes (e.g., question writing training) that could be made to exam question writing for the November 2002 exam and additional changes that could be implemented by May 2003 and subsequent exams. The task force should also solicit and encourage SOA participation with the CAS in this area. Examination Committee Chairperson Thomas Myers should communicate changes and ideas between the Task Force and Joint Exam Administration Committee.

- **Syllabus**

The Board asked the Task Force to:

- Consider endorsement of existing study materials created by independent vendor(s);
- Identify areas where new study notes are needed, and develop a potential plan for commissioning such notes;
- Open discussions with the SOA of shifting material between Exam 3 and 4 to preserve a joint exam 3 and allow for possible independent Exams 4;
- Reassess learning objectives for Exams 3 and 4; and
- Solicit and encourage SOA collaboration with the CAS in this area.

- **Planning for Change**

The Board asked the Task Force to:

- Develop benchmarks for monitoring performance of changes;
- Consider transition issues to minimize disruption;
- Discuss administration of independent exams;

- Develop marketing for independent exams; and
 - Consider impact of recommended changes on QRA and IAA qualifications.
- **Communication**

The Board asked the Task Force to develop an ongoing communication plan to report on the progress on Exams 3 and 4.

History

In 1995, the CAS Executive Council created the Task Force on Education to determine if changes were needed to educate the casualty actuary of the future and to analyze the Society of Actuaries' proposed restructuring of SOA exams. The CAS worked with the SOA on Exams 1-4. In its 1997 report, the Task Force on Education noted that there was much common material with the SOA on Exams 3 and 4, but that the emphases were different and recommended that Exams 3 and 4 not be jointly administered.

There was feedback to the Board that it would be beneficial for candidates and employers if the first four exams were jointly administered. The two societies worked together and in 1998 agreed to jointly administered Exams 3 and 4. In a compromise, some material was moved between Exams 3 and 4 so that the current exams differ slightly from the original proposal of 1997.

When a decision was made that Exams 3 and 4 would be jointly administered, there was only a year and a half to implement them.

The study materials were not as appropriate for self-study as anticipated and there was a firestorm of e-mails. Some suggested that candidates not take new Exams 3 and 4. Some candidates lost credits in the transition. There was controversy before the first exam was administered. Registrations and pass rates were down for the first administration.

The first CAS task force on Exams 3 and 4 met before the first exam administration. The first task force recommended that some material be eliminated and identified some material that was not good for self-study or not appropriate for these exams. Much material was eliminated. A subsequent task force developed a contingency plan in case the normal avenue of change was found to be insufficient by the Board. The task force presented two recommendations to the Board, neither of which were implemented. A third task force was formed to create a CAS version of Exam 3 to be implemented in November 2001. The task force finalized a CAS-only Exam 3 but the CAS decided not to implement it.

A study note for Exam 3 was written in response to CAS Board concerns. In December 2001, there was an announcement that the study note would replace some of the existing material for the Spring 2002 examinations. Another study note for Exam 4 is in the final stages of development.

Task Force Members

The Task Force was chaired by Nancy Braithwaite. Task Force members were Todd Bault, Curtis Gary Dean, Russell Frank, Rebecca Hai, Keith Holler, Clive Keatinge, Allan Kerin, Gary LaRose, Scott Lefkowitz, Roosevelt Mosley, Dylan Place, Manalur Sandilya, Glenn Walker, Dean Westpfahl, and Robert Wolf.

Work Plan

The Task Force members initially focused their work on evaluating the general topics covered by Exams 3 and 4. After making recommendations on the appropriateness of the topics, the associated learning objectives and readings were reviewed and the exam questions were discussed. Based on the individual recommendations, the Task Force members created a unified plan, recommending removal of some items and shifting of other topics and material between the exams.

Concurrent Activities

There are other groups considering various aspects of the CAS education process.

- **Quantitative Risk Analyst**

The QRA designation is being discussed on an international level by the CAS, SOA, Faculty and Institute of Actuaries (UK), and the Institute of Actuaries of Australia. The QRA concept is being reviewed by the CAS Education Policy Committee and the Future Education Task Force. The Task Force considered its final recommendations in light of the current QRA proposal.

- **Future Education Task Force**

This task force is focusing on the needs of casualty actuaries of the future, looking at changes for 2005 and beyond. Some longer-term recommendations from the Design Task Force on Exams 3 and 4 were forwarded to the Future Education Task Force for consideration. Dean Westpfahl was the Design Task Force liaison to the Future Education Task Force. Gary Dean and Clive Keatinge served on both task forces.

- **SOA Education Working Groups**

The SOA Board created a Preliminary Education Working Group that is working with other organizations and various practice areas. The CAS has four voting representatives on this group that will also consider the QRA proposal. Manalur Sandilya, a member of the Design Task Force, is an official CAS member of PEWG.

- **Syllabus Committee**

The CAS Syllabus Committee is responsible for the content of the syllabus or readings. For joint exams, the appropriate members of this committee also serve on the joint CAS/SOA Preliminary Actuarial Examinations Syllabus and Education Committee. Syllabus Committee Chairperson Edward Stone participated in most of the Task Force telephone conferences.

Recommendations

Structure

The Task Force recommends that the material continue to be tested on two exams. The structure of the *Loss Models* textbook does not follow the division of material on Exams 3 and 4. The study materials should follow the structure of the exams and, conversely, the exams should reflect the presentation of the material.

General Topics

The aggregate of recommendations related to the topics is presented in three sections: General Topics, Learning Objectives, and Readings. The Task Force makes the following recommendations on the current topics.

□ Exam 3, Actuarial Models

- A. **Classification of Models:** This topic should be deleted. Descriptive text from this section should be retained and moved to the introductory paragraphs for Exam 3.
- B. **Contingent Payment Models:** The Task Force discussed how much material on life contingencies and survival models a casualty actuary needs and why. The discussion included the following options:
 1. **Bare minimum:** A basic amount is needed for both workers compensation and general principles (CIA requirements, public expectations, international syllabus, etc.). This level would include:
 - Survival distributions
 - Integral survival probabilities (i.e., what is a mortality table, $p_{sub x}$)
 - Definitions of types of life insurance and annuities
 - Expected values of life insurances and annuities, but not variance
 - Interaction of probability distribution with discounting for time value of money (This is useful in its own right, and the CAS does not currently cover discounted expected value in a loss distribution context elsewhere)
 - Workers compensation application, e.g., at the level of the R.H. Snader paper (“Reserving Long Term Medical Claims,” *Proceedings of the Casualty Actuarial Society*, LXXIV, 1987, pp. 322-352)
 2. **Approximate level of old CAS Part 4A:** This option demonstrates that the CAS would like its members to understand life contingencies, but candidates do not need the level of detail and mastery traditionally tested by the old SOA Course 150. This level would include:
 - All material for the bare minimum option (including the workers compensation example)
 - Periodic payment of premiums

- Reserves
- Multiple lives
- Multiple decrements

For each of these, there are questions about the appropriate level of coverage. For an intermediate level, the CAS should at least cover the basic definitions, expected values, and the variances. The inclusion of variances would indicate the use of the Bowers text. It would be difficult to avoid the International Actuarial Notation found in Bowers that is now standard and not particularly difficult. Candidates understand the material. This level stops short of the current exam because questions are easier, especially on the later topics, and only the most basic part of multiple decrements is covered.

3. **Continue with the current coverage (with minor adjustments):** As noted above, this option includes only a minimal amount of material that was not covered on old CAS Part 4A, including the Balducci assumption, adjustment to a monthly payment basis, more advanced reserve calculations, common shock multiple life model, and single decrement factors $p^{(i)}$ for the multiple decrement model. The real issue is the level of proficiency required. The current exam goes beyond a basic knowledge of the topics. However, as this exam continues to evolve, both societies would like to focus on testing key concepts, although in practice this proves to be more difficult to accomplish than in theory.

Recommendation

After debating the various options, the Task Force recommends that the topic of Contingent Payment Models should be combined with Survival Models. The syllabus for the combined topic should be at roughly the level of comprehension that was required from old CAS Part 4A. The Syllabus and Examination Committees should consider whether tables of formulae should be provided with the exam itself rather than be memorized by candidates. Although the Task Force concluded that the optimal level of coverage is similar to old CAS Part 4A, there was a strong consensus that if this topic is the only issue impeding joint administration of this exam with the Society of Actuaries, the current coverage on the joint exam is *not* excessive.

Pension Mathematics

In addition, the Task Force discussed adding pension mathematics to be presented in conjunction with contingent payments. This topic would be helpful in understanding benefit reserves as well as the similarities between pension funds and property-casualty loss reserves. Additionally, as the CAS develops the concept of Enterprise Risk Management, casualty actuaries may become more involved in the assessment of pension funding valuation and funding risk issues.

In discussion, the following views on the level of importance of this topic emerged.

Pension mathematics:

- is not of sufficient importance to casualty actuaries to be included in the CAS syllabus;

- is of sufficient importance to casualty actuaries that it be referred to the Future Education Task Force for consideration; and
- is of importance to casualty actuaries as a significant specialty within the global insurance industry and, therefore, casualty actuaries should have a rudimentary understanding of the funding and valuation techniques found therein.

Recommendation

After much discussion, the Task Force voted 7-4 to recommend to the Board of Directors that an introductory treatment of pension mathematics be included with contingent payments without increasing the overall volume of the current material. The Task Force reviewed *A Problem-Solving Approach to Pension Funding and Valuation* by William H. Aitken but did not agree on whether to recommend it. Therefore, the Syllabus Committee or other appropriate group should be asked to recommend appropriate material.

- C. **Survival Models:** This topic should be combined as described above.
- D. **Frequency and Severity Models:** The topic is appropriate and should be kept. The Task Force recommends the inclusion of Lee Diagrams with this topic and has made such a recommendation to the Syllabus Committee and the Future Education Task Force to consider.
- E. **Compound Distribution Models:** The topic is appropriate and should be kept. The Task Force recommends the inclusion of the Fast Fourier Transform with this topic and has made such a recommendation to the Syllabus Committee and the Future Education Task Force to consider.
- F. **Stochastic Process Models:** With the current level of coverage on this topic, candidates would not be able to create a model and would consult an expert to do modeling. The Task Force recommends that this topic will be deleted. Candidates will learn the underlying theory in other sections of the syllabus. If the CAS develops a required DFA seminar, an introductory note on stochastic processes may be appropriate on this exam.
- G. **Ruin Models:** The topic is appropriate but should be treated in less depth. Only a basic introduction should be included.
- H. **Simulation of Models:** The topic is appropriate but the emphasis should be changed to how a candidate can determine whether a simulation has gone wrong.

□ Exam 4, Actuarial Modeling

- A. **Modeling Process:** This topic should be deleted. Descriptive text from this section should be retained and moved to the introductory paragraphs for Exam 4.
- B. **Estimation and Fitting of Models:** The topics are appropriate but the readings are not ideal. *Loss Models* and *Survival Analysis* will be replaced with a study note that is currently in process.
- C. **Regression, Forecasting and Time Series:** The topics are appropriate.
- D. **Credibility Theory:** The topic is appropriate.
- E. **Simulation in Estimation and Fitting:** For future consideration, all simulation should be presented on one exam.

Learning Objectives

Based on the recommendations above, the Task Force makes the following recommendations for the current learning objectives.

□ Exam 3, Actuarial Models

Understanding Actuarial Models

The candidate is expected to understand the models and techniques listed below and to be able to apply them to solve problems set in a business context. The effects of regulations, laws, accounting practices and competition on the results produced by these models are not considered in this course. The candidate is expected to be able to:

1. *Explain what a mathematical model is and, in particular, what an actuarial model can be.*
2. *Discuss the value of building models for such purposes as: forecasting, estimating the impact of making changes to the modeled situation, estimating the impact of external changes on the modeled situation.*
3. *Identify the models and methods available, and understand the difference between the models and the methods.*
4. *Explain the difference between a stochastic and a deterministic model and identify the advantages/disadvantages of each.*
5. *Understand that all models presented (e.g., survival models, stochastic processes, aggregate loss models) have the same structure.*

Recommendation: Delete learning objectives 1-5.

6. *Formulate a model for the present value, with respect to an assumed interest rate structure, of a set of future contingent cash flows. The model may be stochastic or deterministic.*
7. *Determine the characteristics of the components and the effects of changes to the*

components of the model in 6. Components include:

- *A deterministic interest rate structure;*
- *A scheme for the amounts of the cash flows;*
- *A probability distribution of the times of the cash flows; and*
- *The probability distribution of the present value of the set of cash flows.*

Recommendation: Keep learning objectives 6 and 7.

8. *Apply a principle to a present value model to associate a cost or pattern of costs (possibly contingent) with a set of future contingent cash flows.*

- *Principles include: equivalence, exponential, standard deviation, variance, and percentile.*
- *Models include: present value models based on 9-12 below.*
- *Applications include: insurance, health care, credit risk, environmental risk, consumer behavior (e.g., subscriptions), and warranties.*

Recommendation: [Probably belongs but decision will be deferred until there is a resolution on the old Part 4A material about whether to include variance and percentiles.]

9. *Characterize discrete and continuous univariate probability distributions for failure time random variables in terms of the life table functions, l_x , q_x , p_x , ${}_nq_x$, ${}_np_x$, and ${}_m|_nq_x$, the cumulative distribution function, the survival function, the probability density function and the hazard function (force of mortality), as appropriate.*

- *Establish relations between the different functions.*
- *Develop expressions, including recursion relations, in terms of the functions for probabilities and moments associated with functions of failure time random variables, and calculate such quantities using simple failure time distributions.*
- *Express the impact of explanatory variables on a failure time distribution in terms of proportional hazards and accelerated failure time models.*

Recommendation: Keep learning objective 9.

10. *Given the joint distribution of two failure times:*

- *Calculate probabilities and moments associated with functions of these random variables.*
- *Characterize the distribution of the smaller failure time (the joint life status) and the larger failure time (the last survivor status) in terms of functions analogous to those in 9, as appropriate.*
- *Develop expressions, including recursion relations, for probabilities and moments of functions of the joint life status and the last survivor status, and express these in terms of the univariate functions in 9 in the case in which the two failure times are independent.*
- *Characterize the joint distribution of two failure times, the joint life status and the last survivor status using the common shock model and using copulas.*

Recommendation: The concept should be kept. It is expected to be included as part of the international basic education learning objectives for actuaries. This section should be at a

level appropriate for workers compensation reserving. Delete the last bullet (“Characterize the joint distribution...”).

11. Characterize the joint distribution (pdf and cdf) of the time until failure and the cause of failure in the competing risk (multiple decrement) model, in terms of the functions $l_x^{(\mathbf{t})}$, ${}_tq_x^{(\mathbf{t})}$, ${}_tp_x^{(\mathbf{t})}$, ${}_td_x^{(\mathbf{t})}$, ${}_tm^{(\mathbf{t})}(t)$.
- Establish relations between the functions.
 - Given the joint distribution of the time of failure and the cause of failure, calculate probabilities and moments associated with functions of these random variables.
 - Apply assumptions about the pattern of failures between integral ages to obtain the associated (discrete) single decrement models from a discrete multiple decrement model as well as the discrete multiple decrement model that results from two or more discrete single decrement models.

Recommendation: Keep learning objective 11.

12. Generalize the models of 9, 10, and 11 to multiple state models characterized in terms of transition probability functions or transition intensity functions (forces of transition).

Recommendation: Delete learning objective 12. The Markov Process and the paper on long-term care are no longer covered.

13. Define a counting distribution (frequency distribution).
- Characterize the following distributions in terms of their parameters and moments: Poisson, mixed Poisson, negative binomial, binomial, and the (a,b,1) class of distributions.
 - Identify the applications for which these distributions are used and the reasons why they are used.
 - Given the parameters of a distribution, apply the distribution to an application.

Recommendation: Delete the (a,b,1) class of distributions from the first bullet. Keep the remainder of learning objective 13, changing the word “define” to a more appropriate term. Based on the Task Force’s recommendations on stochastic processes, the following should be incorporated into learning objective 13 as a fourth bullet:

- Characterize a Poisson process in terms of the distribution of the waiting times between events; the distribution of the process increments; and the behavior of the process over an infinitesimal time interval.

14. Define a loss distribution.
- Characterize the following families of distributions in terms of their parameters and moments: transformed beta, transformed gamma, inverse transformed gamma, lognormal and inverse Gaussian.
 - Apply the following techniques for creating new families of distributions: multiplication by a constant, raising to a power, exponentiation, and mixing.
 - Identify the applications in which these distributions are used and the reasons why

they are used.

- *Given the parameters of a distribution, apply the distribution to an application.*

Recommendation: Keep learning objective 14, changing the word “define” to a more appropriate term. Based on the Task Force’s recommendations on stochastic processes, the following should be incorporated into learning objective 14 as a fifth bullet:

- Define a compound Poisson process. Calculate moments associated with the value of the process at a given time. Characterize the value of the process at a given time as a compound Poisson random variable.

15. Define a compound distribution.

16. Calculate probabilities associated with a compound distribution when the compounding distribution is a member of the families in 13, and the compounded distribution is discrete or a discretization of a continuous distribution.

17. Adjust the calculation of 16 for the impact of policy modifications such as deductibles, policy limits and coinsurance.

Recommendation: Keep learning objectives 15-17. In objective 15, the word “define” should be changed to a more appropriate term.

18. Define a stochastic process and distinguish between discrete-time and continuous-time processes.

19. Characterize a discrete-time Markov chain in terms of the transition probability matrix.

- *Use the Chapman-Kolmogorov equations to obtain probabilities associated with a discrete-time Markov chain.*
- *Classify the states of a discrete-time Markov chain.*
- *Calculate the limiting probabilities of a discrete-time Markov chain.*

20. Define a counting process.

21. Characterize a Poisson process in terms of:

- *The distribution of the waiting times between events;*
- *The distribution of the process increments; and*
- *The behavior of the process over an infinitesimal time interval.*

22. Define a nonhomogeneous Poisson process.

- *Calculate probabilities associated with numbers of events and time periods of interest.*

23. Define a compound Poisson process.

- *Calculate moments associated with the value of the process at a given time.*
- *Characterize the value of the process at a given time as a compound Poisson random variable.*

24. *Define a Brownian motion process.*

- *Determine the distribution of the value of the process at any time.*
- *Determine the distribution of a hitting time.*
- *Calculate the probability that one hitting time will be smaller than another.*
- *Define a Brownian motion process with drift and a geometric Brownian motion process.*

Recommendation: Learning objectives 18, 19, 20, 22, and 24 should be deleted. Learning objectives 21 and 23 should be incorporated into learning objectives 13 and 14 as described above.

25. *For a discrete-time surplus process:*

- *Calculate the probability of ruin within a finite time by a recursion relation.*
- *Analyze the probability of ultimate ruin via the adjustment coefficient and establish bounds.*

26. *For a continuous-time Poisson surplus process:*

- *Derive an expression for the probability of ruin assuming that the claim amounts are combinations of exponential random variables.*
- *Calculate the probability that the surplus falls below its initial level, determine the deficit at the time this first occurs, and characterize the maximal aggregate loss as a compound geometric random variable.*
- *Approximate the probability of ruin using the compound geometric recursion.*
- *Analyze the probability of ruin: analytically (e.g., adjustment coefficient); numerically; and by establishing bounds.*
- *Determine the characteristics of the distribution of the amount of surplus (deficit) at: first time below the initial level; and the lowest level (maximal aggregate loss).*

27. *Analyze the impact of reinsurance on the probability of ruin and the expected maximum aggregate loss of a surplus process.*

Recommendation: Combine learning objectives 25-27 into one learning objective that focuses on an introduction to ruin theory.

28. *Generate discrete random variables using basic simulation methods.*

29. *Generate continuous random variables using basic simulation methods.*

Recommendation: Keep learning objectives 28 and 29.

30. *Construct an algorithm to appropriately simulate outcomes under a wide variety of stochastic models.*

Recommendation: Delete learning objective 30.

Applications of Actuarial Models

The candidate is expected to be able to apply the models above to business applications. The candidate should be able to determine an appropriate model for a given business

problem and be able to determine quantities that are important in making business decisions, given the values of the model parameters. Relevant business applications include, but are not limited to:

- *Premium (rate) for life insurance and annuity contracts;*
- *Premium (rate) for accident and health insurance contracts;*
- *Premium (rate) for casualty (liability) insurance contracts;*
- *Premium (rate) for property insurance contracts;*
- *Rates for coverages under group benefit plans;*
- *Loss reserves for insurance contracts;*
- *Benefit reserves for insurance contracts;*
- *Resident fees for Continuing Care Retirement Communities (CCRCs);*
- *Cost of a warranty for manufactured goods;*
- *Value of a financial instrument such as: a loan, a stock, an option, etc.;*
- *Risk classification; and*
- *Solvency (ruin).*

Recommendation: Delete “Resident fees for Continuing Care Retirement Communities.” If the Board of Directors accepts the Task Force’s recommendation to include pension mathematics on Exam 3, “Basic pension funding and valuation methods” will be added to the list above.

□ Exam 4, Actuarial Modeling

Understanding Actuarial Models

The candidate is expected to apply statistical methods to sample data to quantify and evaluate the models presented on Exam 3 and to use the models to solve problems set in a business context. The effects of regulations, laws, accounting practices and competition on the results produced by these models are not considered in this exam. The candidate is expected to be able to:

1. *Identify the steps in the modeling process and discuss how they interrelate.*
2. *Identify the models and methods available, and understand the difference between the models and the methods.*
3. *Explain the difference between a stochastic and a deterministic model and identify the advantages/disadvantages of each.*
4. *Discuss the possible limitations imposed by the data available for input for constructing a model.*
5. *Understand that all models presented in Exams 3 and 4 have the same structure. Apply models from more than one family (e.g., regression, stochastic process, time series) to a particular business application.*
6. *Identify the underlying assumptions implicit in each family of models and recognize which set(s) of assumptions are applicable to a given business application.*

Recommendation: Delete learning objectives 1-6.

7. *Estimate the parameters of a tabular failure time or loss distribution when the data is complete, or when it is incomplete, using maximum likelihood, method of moments, and Bayesian estimation.*
8. *Obtain nonparametric estimates for a failure time or loss distribution using the empirical distribution, the Kaplan-Meier estimator and the Nelson-Aalen estimator.*
9. *Construct the likelihood model needed to estimate the parameters of a parametric failure time or loss distribution regression model.*
10. *Construct the partial likelihood model needed to estimate the regression coefficients in a semiparametric failure time or loss distribution regression model.*
11. *Adjust an estimation based on the presentation of the sample data: complete, incomplete, censored, truncated, grouped, shifted.*
12. *Apply statistical tests to determine the acceptability of a fitted model:*
 - *Pearson's chi-square statistic*
 - *Likelihood ratio test*
 - *Kolmogorov-Smirnov statistic*
13. *For estimators, define the terms: efficiency, bias, consistency, mean squared error.*
14. *Calculate the least squares estimates of the parameters used in single and multiple linear regression models, and use knowledge of their distributions for hypothesis testing and development of confidence intervals.*
15. *Test a given linear regression model's fit to a given data set.*
16. *Assess the appropriateness of the linear regression model for a given data set by checking for such irregularities as heteroscedasticity, serial correlation, and multicollinearity.*
17. *Develop deterministic forecasts from time series data, using simple extrapolation and moving average models, applying smoothing techniques and seasonal adjustment when appropriate.*
18. *Use the concept of the autocorrelation function of a stochastic process to test the process for stationarity.*
19. *Generate a forecast using the general ARIMA model and develop confidence intervals for the forecast.*
20. *Test the hypothesis that a given stochastic process is a random walk.*
21. *For an ARIMA process (including simpler models as special cases), estimate the model parameters, and perform appropriate diagnostic checks of the model.*
22. *Apply limited fluctuation (classical) credibility including criteria for both full and partial credibility.*
23. *Perform Bayesian analysis using discrete and continuous examples.*
24. *Apply the Buhlmann-Straub credibility model to basic situations. Understand the*

relationship to the Bayesian model.

25. *Apply the conjugate prior in Bayesian analysis and Buhlmann-Straub credibility, and, in particular, to the Poisson-gamma model.*
26. *Apply empirical Bayesian methods in the nonparametric and semiparametric cases.*
27. *Compare and contrast the assumptions underlying limited fluctuation credibility, Bayesian analysis, and the Buhlmann-Straub credibility model.*
28. *Determine an appropriate number of simulations to perform in order to estimate a quantity of interest.*
29. *Quantify the variability of an estimate in the context of simulation.*
30. *Determine the bootstrap estimates of the mean squared error of an estimator.*

Recommendation: Keep learning objectives 7-30.

31. *Use basic simulation methods to validate a model.*

Recommendation: Delete learning objective 31.

Applications of Actuarial Models

The candidate is expected to apply the models presented in Exam 3 and the statistical methods presented on this exam to business applications. As discussed above, the candidate should be able to take data from a given application and determine a suitable model, including parameter estimates, for use in making business decisions related to the application. The candidate should be able to assess the variability of the parameter estimates and the goodness of fit of the model, and therefore provide an opinion on the confidence that should be given to the model output in making decisions. Relevant business applications include, but are not limited to:

- *Premium (rate) for life insurance and annuity contracts;*
- *Premium (rate) for accident and health insurance contracts;*
- *Premium (rate) for casualty (liability) insurance contracts;*
- *Premium (rate) for property insurance contracts;*
- *Rates for coverages under group benefit plans;*
- *Loss reserves for insurance contracts;*
- *Benefit reserves for insurance contracts;*
- *Resident fees for Continuing Care Retirement Communities (CCRCs);*
- *Cost of a warranty for manufactured goods;*
- *Value of a financial instrument such as: a loan, a stock, an option, etc.; and*
- *Risk classification.*

Recommendation: Delete “Resident fees for Continuing Care Retirement Communities.” If the Board of Directors accepts the Task Force’s recommendation to include pension mathematics on Exam 3, “Basic pension funding and valuation methods” will be added to the list above.

Readings

The Task Force reviewed the current syllabus readings for Exams 3 and 4. The readings were critiqued on their coverage and depth of the specified topic as well as their suitability for self-study.

The Task Force discussed whether the CAS should endorse existing study aids created by independent vendors. The task force was unanimously opposed to this practice. Study notes should be created under the direction of the Syllabus Committee to meet the objectives specified by the Syllabus Committee. When they do, the study notes should be specifically added to the syllabus. There was a question about whether there is sufficient funding available for new study notes. This is particularly important when the addition of a study note to the syllabus may decrease the potential author's other income.

The Task Force was concerned that an author may not commit time and resources to creating study materials for an exam that could be replaced by a new exam structure shortly after completion of the requested product. Before soliciting study note authors, the CAS should commit to the value of the topic to be included on the syllabus.

Based on the review of the syllabus readings and its own recommendations regarding related topics and learning objectives, the Task Force makes the following recommendations.

□ Exam 3, Actuarial Models

A. Classification of Models

The Task Force recommends that this category and background reading be deleted.

Background reading: Jones, B.L., "Actuarial Models and Modeling: An Interactive Approach" (CD-ROM), 2000, ACTEX Publications. (This reference is not required but may be a valuable tool to explore actuarial models and modeling techniques relevant to this exam.)

B. Contingent Payment Models

The Task Force recommends that this section be combined with the following section on Survival Models. It should be presented at a level roughly equivalent to old Part 4A. The Task Force recommends that the Syllabus Committee continue its search to see if a more suitable text exists that could replace the *Actuarial Mathematics* citation for this topic. The Task Force reviewed *Life Insurance Mathematics* by Hans U. Gerber but there was no consensus to recommend it at this time; there was consensus that the Syllabus Committee should address the issue of replacing the text if a more appropriate text is available.

Bowers, N.L.; Gerber, H.U.; Hickman, J.C.; Jones, D.A.; and Nesbitt, C.J., Actuarial Mathematics (Second Edition), 1997, Society of Actuaries, Chapter 4, Sections 5.1-5.4, 6.1-6.4, 7.1-7.6, 8.1-8.4, Sections 9.1-9.5, 9.6 (excluding 9.6.2), 9.7-9.8, Chapter 10 (excluding 10.5.2 and 10.5.5), Sections 11.1-11.3.

C. Survival Models

The Task Force recommends that this section be combined with the above section on Contingent Payment Models with the readings as recommended above.

Bowers, N.L.; Gerber, H.U.; Hickman, J.C.; Jones, D.A.; and Nesbitt, C.J., Actuarial Mathematics (Second Edition), 1997, Society of Actuaries, Chapter 3.

D. Frequency and Severity Models

The Task Force recommends that *Loss Models* be replaced with a study note. The study note should include Lee Diagrams. The Task Force ranked its preferences on how Lee Diagrams could be added to the syllabus:

- Add Lee Diagrams to the current study note.
- Add Lee Diagrams by having a special study note written.
- Add Lee Diagrams by using only a portion of Y.S. Lee's paper ("The Mathematics of Excess of Loss Coverages and Retrospective Rating, A Graphical Approach," *Proceedings of the Casualty Actuarial Society* LXXV, 1988, pp. 49-77).

Klugman, S.A.; Panjer, H.H.; and Willmot, G.E., Loss Models: From Data to Decisions, 1998, John Wiley and Sons, New York, Sections 1.3, 3.1, 3.2.1-3.2.2, 3.3.1-3.3.2, 3.4.1, 3.5 (through first full paragraph on p. 222), 3.7 (excluding Examples 3.15, Theorem 3.4, Example 3.18 and following), 3.10.1 (excluding Example 3.34 and following), 3.10.2 (excluding Example 3.38 and following).

Klugman, S.A., "Course/Exam 3 Study Note Replacing Chapter 2 Material from Loss Models," 2001.

E. Compound Distribution Models

- The Task Force recommends that *Loss Models* be replaced with a study note. The study note should include a basic introduction to the Fast Fourier Transform.

Klugman, S.A.; Panjer, H.H.; and Willmot, G.E., Loss Models: From Data to Decisions, 1998, John Wiley and Sons, New York, Sections 1.4, 4.1-4.3, 4.5, 4.6 (excluding Theorem 4.4 and Sections 4.6.2-4.6.5), 4.8.

F. Stochastic Process Models

The Task Force recommends that this topic be deleted and that the citation below be removed from the syllabus of readings. The Task Force notes that there is an adequate introduction to stochastic processes in the *Loss Models* text. The Task Force found that the presentation of stochastic process models in *Introduction to Probability Models* is better than that in *Loss Models* but felt that it is not worth the cost of keeping the Ross text only for its coverage of this topic.

Ross, S.M., Introduction to Probability Models (Seventh Edition), 2000, Academic Press, San Diego, Sections 2.8, 4.1-4.4, 4.5.1, 4.6, 5.3-5.4, 10.1-10.3.

G. Ruin Models

The Task Force recommends that the current citation from *Actuarial Mathematics* be deleted immediately. The remaining material should be replaced by an introductory study note but is adequate until such a study note can be developed.

Bowers, N.L.; Gerber, H.U.; Hickman, J.C.; Jones, D.A.; and Nesbitt, C.J., Actuarial Mathematics (Second Edition), 1997, Society of Actuaries, Chapter 13 (excluding autoregressive discrete-time model and Appendix).

Klugman, S.A.; Panjer, H.H.; and Willmot, G.E., Loss Models: From Data to Decisions, 1998, John Wiley and Sons, New York, Sections 6.2.3, 6.3.1, 6.3.2.1.

H. Simulation of Models

The Task Force finds this text to be appropriate but the citation should be pared down. It also recommends that the emphasis should be changed to how a candidate can determine whether a simulation is working as expected. The preferred order of methods to convey this topic would be:

- Create a new study note.
- Incorporate topic into next edition of *Loss Models*.
- Pare down material that currently is listed in *Simulation*.

Ross, S.M., Simulation (Third Edition), 2002, Academic Press, San Diego, Sections 3.1, 4.1-4.3, Chapter 5 (excluding 5.3 and 5.5).

□ Exam 4, Actuarial Modeling

A. The Modeling Process

The Task Force recommends that this category and background reading be deleted.

Background reading: Jones, B.L., "Actuarial Models and Modeling: An Interactive Approach" (CD-ROM), 2000, ACTEX Publications. (This reference is not required but may be a valuable tool to explore actuarial models and modeling techniques relevant to this exam.)

B. Estimation and Fitting of Models

The Task Force recommends that *Survival Analysis* and *Loss Models* be replaced by the study note that is being written and is anticipated to be placed on the syllabus for the Spring 2003 exam.

Klein, J.P.; and Moeschberger, M.L., Survival Analysis, 1997, Springer-Verlag, New York, Chapters 4, 5 (excluding 5.2), 6 (excluding 6.4), Sections 7.1-7.3, and Chapter 8. Note: Some notation and definitions used in Survival Analysis are introduced in Chapters 2 and 3 (excluding Section 3.6). The candidate may find it helpful to refer to these chapters when studying later sections of the text.

Klugman, S.A.; Panjer, H.H.; and Willmot, G.E., Loss Models: From Data to Decisions, 1998, John Wiley and Sons, New York, Sections 2.2-2.3, 2.4 (excluding method of scoring), 2.5 (excluding 2.5.3), 2.6, 2.8 (excluding pp. 111 and following), 2.9-2.10, 3.2.3, 3.3.3, 3.4.2, 3.5, 3.10.1 (beginning with Example 3.34).

C. Regression, Forecasting, and Time Series

The Task Force finds *Econometric Models and Economic Forecasts* to be a satisfactory resource for this topic.

Pindyck, R.S.; and Rubinfeld, D.L., Econometric Models and Economic Forecasts (Fourth Edition), 1998, Irwin McGraw-Hill, Boston, Chapters 3-6, 15-18.

D. Credibility Theory

The Task Force recommends that “An Examination of Credibility Concepts” be kept. The remaining material consists of two optional courses of readings, neither of which is complete. The Task Force recommends that the Syllabus Committee consider measures that would allow each option to stand alone.

Background Readings

Philbrick, S.W., “An Examination of Credibility Concepts,” PCAS LXVII, 1981, pp. 195-212.

Klugman, S.A.; Panjer, H.H.; and Willmot, G.E., Loss Models: From Data to Decisions, 1998, John Wiley and Sons, New York, Sections 1.5 and 5.1.

Mahler, H.C.; and Dean, C.G., “Credibility,” Foundations of Casualty Actuarial Science (Fourth Edition), 2001, Casualty Actuarial Society, Chapter 8, Section 1 .

Readings

Mahler, H.C.; and Dean, C.G., “Credibility,” Foundations of Casualty Actuarial Science (Fourth Edition), 2001, Casualty Actuarial Society, Chapter 8, Section 2.

The candidate may use either course of reading (1) or (2) listed below for the remainder of the credibility material. The candidate will not be tested on the details of derivations in either course of reading.

Option 1

Klugman, S.A.; Panjer, H.H.; and Willmot, G.E., Loss Models: From Data to Decisions, 1998, John Wiley and Sons, New York, Sections 5.4 and 5.5 (excluding 5.4.6 and 5.5.3).

Option 2

Mahler, H.C.; and Dean, C.G., “Credibility,” Foundations of Casualty Actuarial Science (Fourth Edition), 2001, Casualty Actuarial Society, Chapter 8, Sections 3-5; and Klugman, S.A.; Panjer, H.H.; and Willmot, G.E., Loss Models: From Data to Decisions, 1998, John Wiley and Sons, New York, Sections 5.4.4. and 5.5 (excluding 5.5.3).

E. Simulation in Estimation and Fitting

This reading, or a section thereof, should be combined with the simulation section of Exam 3 as described above.

Ross, S.M., Simulation (Third Edition), 2002, Academic Press, San Diego, Chapters 7 and 9 (excluding 9.4).

Examination Construction

The Task Force reviewed Exams 3 and 4 for 2000 and 2001. Generally the Task Force believes that the level at which the learning objectives are tested is appropriate. The questions are not too theoretical. The nature of some of the materials lends itself to memorization and this is appropriate.

The Task Force makes the following recommendations:

- Both exams should continue to be administered in a four-hour period. Exams administered in less time would not be effective in testing the material.
- The exam should be constructed so that a high percentage of candidates should finish the exam.
- The Examination Committee should consider incorporating essay questions in the exams.

The exam blueprint for Exam 3 should be revised so that life contingencies represents 1.5 to 2 hours of a four-hour exam. The relative weight of other topics will be deferred to the recommendation of the Syllabus Committee after the Board has decided which Task Force recommendations to implement.

On Exams 3 and 4, the Task Force recommends that the Syllabus and Examination Committees consider providing formulas with the exam for the sections on Regression, Forecasting and Time Series and Contingent Payment Models to minimize memorization. Topics that should be tested in a depth different than current practice have been noted in the recommendations above.

The Task Force has not consulted with The Chauncey Group International. The expectation is that the item writer training being developed for the CAS-specific exams could also be used to train item writers for these exams as well.

Implementation

The Society of Actuaries

The Task Force discussed the issue of jointly administering Exams 3 and 4 with the SOA. Candidates and employers like joint exams for the same reason—the ease with which candidates may move from one area to another without penalty.

If the proposed change to the life contingencies material is the only obstacle to jointly administering these exams with the SOA, the level of life contingencies material is not sufficient to warrant separate administration of the exams.

Admissions Committees Representation

The Task Force included members from the CAS Education Policy Committee, Examination Committee, and Syllabus Committee. No significant objections were received from liaisons to these committees.

Implementation Schedule

The Task Force recommends that the suggested deletions be implemented no sooner than the Spring 2003 exam session and that other recommendations be implemented as soon as practical thereafter.

Board Action

The Task Force submits its recommendations to the CAS Board of Directors for consideration. Any authorized changes should be given to the appropriate CAS committee(s) for implementation. The Task Force has concluded its work and asks that it be disbanded.

Planning for Change

As no major changes or transitions have been recommend by this Task Force, no plan for change was developed.