PRELIMINARY EDUCATION PROPOSAL

The Joint CAS/SOA Task Force on Preliminary Education reviewed the proposals prepared by the CAS Future Education Task Force and the SOA Preliminary Education Working Group and developed the following joint proposal for consideration by the Boards of the CAS and SOA.

Current CAS Preliminary Education Structure

The Casualty Actuarial Society preliminary education structure currently consists of four exams:

Prerequisite: Linear Algebra and Statistics

Exam 1 (Joint): Mathematical Foundations of Actuarial Science (Calculus and Probability) (4 hours)

Exam 2 (Joint): Interest Theory, Economics, and Finance (4 hours)

Exam 3 (CAS Only): Actuarial Models (Life Contingencies and Loss Models) (4 hours)

Exam 4 (Joint): Actuarial Modeling (Fitting Models, Credibility, Regression and Time Series) (4 hours)

Proposed CAS Preliminary Education Structure

The structure for CAS preliminary education being proposed by the Joint Task Force is as follows:

Prerequisite: Calculus and Linear Algebra

Validation by Educational Experience (Joint): Economics, Corporate Finance, Applied Statistical Methods

Exam 1 (Joint): Probability (with supporting calculus) (3 hours)

Exam 2 (Joint): Mathematics of Finance (2 hours)

Exam 3 (CAS Only): Statistics and Actuarial Models (4 hours)

Exam 4 (Joint): Actuarial Modeling (Fitting Models and Credibility) (4 hours)

Draft learning objectives for these topics can be found in Appendix 1.

Validation by Educational Experience

Validation by Educational Experience (VEE) is a new process in which candidates would demonstrate knowledge by submitting acceptable evidence of completing university courses and/or exams or courses administered by other organizations. The following topics would be subject to VEE:

> Economics: The requirement will be two semesters, one each of introductory microeconomics and macroeconomics. A one-semester survey course will not qualify.
>
> Corporate Finance: The requirement will typically be met by a course with an introductory corporate finance course as a prerequisite.
>
> Applied Statistical Methods: The course must cover both time series and regressions (or a candidate may submit two courses).

Validation by Educational Experience could be accomplished in one of three ways:

1. Completion, with a pre-set grade, of one or more courses offered by a recognized college or university and approved by the CAS and SOA.
   a. Candidates or faculty members would submit courses for consideration.
   b. Generally, the only documentation required for course approval would be the course description from the catalog, including pre-requisites. At its discretion, the committee making the determination may request additional information.
   c. To earn validation for an approved course, a candidate must receive a grade of B- or better. If the institution does not use letter grading, an appropriate translation will be determined.

2. Achieve a pre-set score on a standardized examination as determined by the CAS and SOA.
   a. Specified score minimums on the Advanced Placement (AP) and College Level Examination Program (CLEP) tests for micro and macroeconomics will be accepted as VEE credit for economics.
   b. The committee responsible for VEE implementation will determine which other examinations qualify and the score required for credit. Additional research will be done regarding options such as the CFA exams.

3. Completion of other educational experiences as approved by the CAS and SOA. The CAS or SOA may choose to offer such experiences. Experiences offered by other vendors would need to be approved by the committee responsible for VEE.

In order to reduce the administrative cost, candidates will not be allowed to submit their VEE evidence until after they have passed two exams. However, there will be no time limit on when VEE experiences were completed.

Transition Rules

The following transition rules would apply to the proposed preliminary education structure:

Current Credit	Credit Under New System
Exam 1	Exam 1
Exam 2	Exam 2 plus VEE for Economics and Corporate Finance
Exam 3	Exam 3
Exam 4	Exam 4 plus VEE for Applied Statistical Methods

Implementation Timeline

The proposed implementation timeline is as follows:

March 2004 – Joint Syllabus groups formed
Late Spring/early Summer 2004 – Final Syllabus details released
Fall 2004 – VEE administration details released
November 2004 – Final administration of current exams
January 2005 – VEE course approval requests may be submitted
May 2005 – First administration of new exams

Submitted by the Joint CAS/SOA Task Force on Preliminary Education

James W. Daniel
Curtis Gary Dean
Stuart Klugman (co-chair)
Warren R. Luckner
Glenn G. Meyers
Thomas G. Myers (co-chair)
Laurence Pinzur
Rajesh V. Sahasrabuddhe

APPENDIX 1: DRAFT LEARNING OBJECTIVES FOR PROPOSED CAS PRELIMINARY EDUCATION STRUCTURE

Exam 1: Probability (Joint with SOA)

Prerequisite: Candidates need to be familiar with the calculus techniques of differentiation (including partial derivatives), integration (including integration involving functions of more than one variable), maximization (minimization), limits, series summation, and have knowledge of the logarithmic and exponential functions.

Candidates will be able to use and apply the following concepts in a risk management context:

- Basic elements of probability, including set notation, Venn diagrams, negation, mutual exclusion, independence, addition and multiplication rules, law of total probability, conditional probability, and Bayes' Theorem.

- Discrete random variables (including binomial, negative binomial, geometric, hypergeometric, and Poisson), their probability functions, distribution functions, moments and moment generating functions; probability and moment values for such random variables.

- Continuous random variables (including uniform, exponential, chi-square, gamma, normal, and bivariate normal), their density functions, distribution functions, moments and moment generating functions; probability and moment values for such random variables.

- Linear combination of independent random variables, and identification of the resulting distributions by use of convolutions and generating functions.

- Central Limit Theorem.

- Multivariate distributions, joint probability, conditional probability, marginal probability, expected value, variance, covariance, and correlation coefficients.

Exam 2: Mathematics of Finance (Joint with SOA)

Candidates will gain an understanding of the fundamental concepts of interest theory, and how those concepts are applied in calculating present and accumulated values for various streams of cash flows as a basis for future use in: reserving, valuation, pricing, duration, asset/liability management, investment income, capital budgeting, and valuing contingent cash flows.

1. Candidates will know definitions of key terms of financial mathematics: inflation; interest - simple, compound, real, nominal, effective, money, forward, term structure; equivalent measures of interest; yield rate; capital/principal; loan; depreciation; cash

flow; equation of value; present value; future value; current value; net present value; annuity certain; project appraisal. Candidates are expected to demonstrate the ability to:

- Choose the term, given a definition.
- Write the definition, given a term.
- Write an equation of value, given a valuation problem involving one or more sets of cash flows at specified times.

2. Candidates will understand key procedures of financial mathematics: determining equivalent measures of interest; discounting; accumulating; amortization; cash flow models for investment returns. Candidates are expected to demonstrate the ability to:

- Calculate the equivalent annual effective rate of interest, given a nominal annual rate and a frequency of interest conversion, discrete or continuous.
- Calculate the appropriate equivalent single value (present value, net present value, future value or combination), given a set of cash flows (level or varying), an appropriate term structure of interest rates, and an appropriate set of inflation rates.
- Calculate the yield rate, given a set of investment cash flows.
- Calculate the principal and interest portions of a loan payment, given the loan amount, the set of loan payments (level or varying), and a set of interest rates (level or varying).
- Calculate the loan amount, given a set of loan payments (level or varying) and a set of interest rates (level or varying).

3. Candidates can apply cash flow models of financial mathematics. Candidates are expected to demonstrate the ability to:

- Calculate appropriate values for a financial transaction, given a cash-flow model that reflects the timing of payments of each of the associated cash flows.
- Calculate appropriate investment project appraisal value using a discounted cash flow model.

4. Candidates will know definitions of key terms of modern financial analysis: yield curves, spot rates, forward rates, duration, convexity and immunization. Candidates are expected to demonstrate the ability to:

- Choose the term, given a definition.
- Write the definition, given a term.
- Perform basic calculations such as measuring interest rate risk using duration and convexity, or basic immunization calculations.

Exam 3: Statistics and Actuarial Models (CAS Only)

Candidates will be able to use and apply the following concepts:

1. Statistics

- Point estimation, including maximum likelihood estimation, method of moments, and the application of criteria such as consistency, unbiasedness, minimum variance and mean square error.
- Tests of statistical hypotheses, including Type I and Type II errors, Neyman-Pearson lemma, and likelihood ratio tests.
- Order statistics and sampling distributions (including the t and F distributions) and their applications to confidence intervals and to tests for means and variances.
- The method of least squares for calculating a linear regression.

2. Simulation

- Simulate both discrete-type and continuous-type random variables by the Inversion (Inverse Transform) Method.
- Apply simulation in the context of topics 3 through 7.
- Estimate the number of simulations needed for a given probability of having at most a given relative error.

3. Survival and severity models

- Determine expected values, variances, probabilities, and percentiles of survival-time random variables (including left-truncated, right-censored, joint-life, and multiple-decrement models) and severity random variables (including policy modifications like deductibles and limits), including mixture distributions.
- Determine probabilities and expected values in discrete-time Markov-chain multiple-decrement models.

4. Frequency models

- Determine expected values, variances, and probabilities of frequency random variables, including Poisson, Binomial, Negative Binomial, Geometric, and mixture distributions.
- Determine expected values, variances, and probabilities for Poisson Processes, sums of Poisson processes, and Poisson Processes resulting from special types of Poisson-Process events.

5. Aggregate (compound) models

- Determine expected values, variances, and probabilities of compound random variables.

- Determine expected values, variances, and probabilities of compound Poisson Processes.

6. Life contingency models

- Determine expected values, variances, and probabilities of present-value-of-benefit random variables for "life" insurances.

- Determine expected values, variances, and probabilities of present-value-of-benefit random variables for annuities.

- Determine considerations (premiums) for "life" insurances and annuities, analyzing the present-value-of-loss-at-issue random variable to obtain values based on the Equivalence Principle or percentiles.

- Analyze present-value-of-future-loss random variables for "life" insurances and determine net liabilities using prospective and retrospective methods.

7. Simple models with stochastic interest rates.

- Determine expected values of present-value random variables incorporating simple models of stochastic interest rates (such as binomial lattices).

- Apply these models to simple "life" insurances and annuities.

NOTE: the SOA version of Exam 3 will contain additional material on Actuarial Models but will not include Statistics.

Exam 4: Actuarial Modeling (Joint with SOA)

Candidates will be able to use and apply the following concepts:

1. Construction of Empirical Models

- Kaplan-Meier and Nelson-Aalen estimates from complete data and from data that have been right-censored and/or left-truncated.
- Pointwise confidence intervals for these estimators using both linear and log-transformed formulas.
- Simple adjustments for working with mass data.

2. Construction and Selection of Continuous, Parametric Models

- Parameter estimation by the method of moments, percentile matching, and maximum likelihood. Included will be the case where the data have been modified through right-censoring and/or left-truncation.
- The information matrix and delta methods to obtain the variances of these estimators.
- Model selection procedures including the likelihood ratio test, information criteria, and goodness-of-fit tests.

3. Adjustment of Estimates

- Classical, Bayesian, and Least-squares credibility, including estimation of key parameters.
- Graduation, in particular, interpolation and Whitaker-Henderson methods.

VEE: Economics (Joint with SOA)

1. Microeconomics

Candidates will know and understand the implications of fundamental microeconomic principles, especially as they relate to markets, regulatory issues and strategic decision-making, in building models for quantifying risk, pricing/funding of financial security products, or valuation of financial security systems.

Specifically, candidates are expected to demonstrate the ability to:

- Explain the interaction between supply and demand in the provision of a product and the way in which equilibrium market prices are determined.
- Define elasticity of demand and supply and explain the effects on a market of different levels of elasticity.
- Explain how rational utility maximizing agents make consumption choices.
- Describe how a financial security system can contribute to individual welfare through reducing the adverse financial impact of future events on the individual.
- Describe how profit maximizing firms make short run and long run production choices.
- Describe what is meant by different types of competition, or lack of it, and explain the practical effect on supply and demand.

2. Macroeconomics

Candidates will know and understand the implications of fundamental macroeconomic principles, especially as they relate to the business cycle, in building models for quantifying risk, pricing/funding of financial security products, or valuation of financial security systems.

Specifically, candidates are expected to demonstrate the ability to:

- Define what is meant by GDP, GNP, and Net National Product.
- Describe how the propensity to save or to consume by the private sector or the corporate sector affects the economy.
- Describe the impact of fiscal and monetary policy and other forms of government intervention on different aspects of the economy, and in particular on financial markets.
- Explain the role of exchange rates and international trade in the economy and the meaning of the term balance of payments.
- Describe, and explain the impact of, the major factors affecting the rate of inflation, the level of interest rates, the exchange rate, the level of unemployment, and the rate of economic growth in the economy of an industrialized country.

VEE: Corporate Finance (Joint with SOA)

The goal of the Corporate Finance course is to provide an understanding of the fundamental concepts of corporate finance, and how those concepts are applied to analyzing financial statements including balance sheets, income statements, and statements of cash flow, assessing financial performance, analyzing financial structures, the valuation of securities, and basic option pricing.

1. Candidates will know definitions of key finance terms: stock company; capital structure; financial instruments – bond, stock, basic options (calls, puts); dividends; price to earnings ratio. Candidates are expected to demonstrate the ability to:

- Choose the term, given a definition.
- Write the definition, given a term.

2. Candidates will understand key finance concepts: financing companies; characteristics and uses of financial instruments; sources of capital; cost of capital; dividend policy; personal and corporate taxation; stock valuation; option pricing theory. Candidates are expected to demonstrate the ability to:

- Describe the structure of a stock company and the different methods by which it may be financed.
- Describe the factors to be considered by a company when deciding on its capital structure and dividend policy.
- Describe the impact of financial leverage and long/short term financing policies on capital structure.
- Describe the characteristics of the principal forms of financial instruments issued or used by companies, and the ways in which they may be issued.
- Describe basic techniques for valuing options such as calls and puts.

- Describe how a company's cost of capital relates to the investment projects the company wishes to undertake.
- Describe the basic principles of personal and corporate taxation.

3. Candidates can apply key models of finance: dividend growth; discounted cash flows; basic techniques for valuing options; Black-Scholes. Candidates are expected to demonstrate the ability to:

- Calculate value of stocks using the dividend growth model.
- Calculate value of stocks using the discounted cash flows model.
- Calculate value of stocks using the price to earnings ratio.
- Calculate value of options using the binomial option valuation model.
- Calculate value of options using the risk neutral method.
- Calculate value of options using Black-Scholes model.

4. Candidates will know the definitions of key financial reporting terms: asset; liability; internal rate of return; balance sheet; income statement; statement of cash flows; financial ratios (e.g. leverage, liquidity, profitability, market value ratios). Candidates are expected to demonstrate the ability to:

- Choose the term, given a definition.
- Write the definition, given a term.

5. Candidates will understand key financial reporting concepts: accounts; analysis of financial performance. Candidates are expected to demonstrate the ability to:

- Describe the basic construction of accounts of different types, and the role and principal features of the accounts of a company.
- Describe various measures of financial performance: balance sheet; income statement; statement of cash flows; financial ratios (e.g. leverage, liquidity, profitability, market value ratios); net present value: the payback, discounted payback models; internal rate of return and profitability index models.

6. Candidates can analyze financial performance. Candidates are expected to demonstrate the ability to:

- Assess financial performance using various measures: balance sheet; income statement; statement of cash flows, financial ratios (e.g. leverage, liquidity, profitability, market value ratios); net present value; the payback, discounted payback models; internal rate of return and profitability index models.

VEE: Applied Statistical Methods (Joint with SOA)

Candidates will understand the methods and be able to conduct and interpret analyses. Candidates are not expected to reproduce formulas.

1. Simple and multiple regression, including model selection, hypothesis tests, residual analysis, and prediction intervals.
2. Forecasts based on time series, including prediction intervals.

APPENDIX 2: CURRENT CAS PRELIMINARY EDUCATION LEARNING OBJECTIVES

Exam 1: Mathematical Foundations of Actuarial Science (Joint with SOA)

The purpose of this examination is to develop a knowledge of the fundamental mathematical tools for quantitatively assessing risk. The application of these tools to problems encountered in actuarial science is emphasized. A thorough command of calculus and probability topics is assumed.

The tools emphasized on Exam 1 are:

- Limits, series, sequences, and functions
- Derivatives of single and multivariate functions (maximums, minimums, constrained maximums and minimums, rate of change)
- Integrals of single and multivariate functions, simple differential equations
- Parameterized curves
- General probability (set functions, basic axioms, independence)
- Bayes' Theorem
- Univariate probability distributions (probabilities, moments, variance, mode, percentiles, transformations)
- Multivariate probability distributions (Central Limit Theorem; joint, conditional and marginal distributions—probabilities, moments, variance, covariance)

Exam 2: Interest Theory, Economics, and Finance (Joint with SOA)

The purpose of this examination is to test the candidate's basic knowledge of economics and finance. Concepts from microeconomics and macroeconomics are fundamental to understanding the general business environment. Basic interest theory and finance are essential to understanding the business of insurance. A basic knowledge of calculus and probability is assumed.

1. Microeconomics

Candidates should be able to use the following microeconomic principles to build models to increase their understanding of the framework of contingent events and to use as a frame for activities such as pricing:

- The shape of the Demand Curve, demand versus quantity demanded, changes in demand, and market demand
- The supply versus quantity supplied equilibrium and the point of equilibrium and changes in the equilibrium point

- Tastes, indifference curves, and the Marginal Rate of Substitution
- Changes in income and the budget line, the Engel Curve
- Changes in price and changes in the budget line, the Demand Curve
- Income and substitution effects, the Compensated Demand Curve, why Demand Curves slope downward
- Decisions under uncertainty such as the following: attitudes toward risk, and the theory of rational expectations
- Adverse selection and moral hazard

Candidates should be able to use knowledge of the following microeconomic principles to increase their understanding of the markets in which we operate and of the regulatory issues. Candidates should also be able to use the following microeconomic principles to increase their understanding of the ramification of strategic decisions:

- The competitive firm, the competitive industry in the short run, revenue, costs and supply, elasticity of supply, and competitive equilibrium
- The competitive firm, the competitive industry in the long run, long-run costs, supply, profits, constant/decreasing-cost industries, and equilibrium
- Sources of monopoly power: natural, patents, resources, and legal barriers
- Oligopoly, contestable markets, a fixed number of firms
- Collusion, game theory, the prisoner's dilemma and the breakdown of cartels
- Monopolistic competition, product differentiation and the economics of location
- Consumers' and producers' surplus economics, theories of value
- Adverse selection and moral hazard

2. Macroeconomics

Candidates should understand the following macroeconomic principles and use them in developing economic models and/or economic assumptions:

- The general accounting conventions and data sources used in tracking economic activity
- The simplified Keynesian model, without adjustments for changes in price level or money supply, as it applies to changes in GDP caused by changes in investment, government spending, and net exports
- The relationship among interest rates, demand for money, consumption and investment using concepts such as the IS/LM curve, fiscal and monetary policy, and how foreign exchange rates affect GDP/NI
- The instruments and processes that shape the money supply including the money multiplier and the role of central banks, and their impact on inflation

Candidates should understand the following macroeconomic principles and how they relate to the business cycle:

- The general accounting conventions and data sources used to track economic activity
- The simplified Keynesian Model, without adjustments for changes in price level or money supply, as it applies to changes in GDP caused by changes in investment, government spending, and net exports
- The relationship of price level, money demand, total demand, and total supply under the Keynesian Model

3. Interest Theory

Candidates should have a practical knowledge of the theory of interest in both finite and continuous time. That knowledge should include how these concepts are used in the various annuity functions, and apply the concepts of present and accumulated value for various streams of cash flows as a basis for future use in reserving, valuation, pricing, duration, asset/liability management, investment income, capital budgeting, and contingencies. Candidates should be able to perform present and accumulated value calculations using non-level interest rates.

Candidates should understand the following principles and applications of interest theory:

- Accumulation function and the special cases of simple and compound interest
- Nominal and effective interest and discount rates, and the force of interest—constant and varying
- Valuation of discrete and continuous streams of payments, including the case in which the interest conversion period differs from the payment period
- Determination of yield rates on investments, both portfolio and investment year methods, and the time required to accumulate a given amount or repay a given loan amount
- Application of interest theory to amortization of lump sums, fixed income securities, depreciation, mortgages, etc.

Candidates should be able to use annuity functions in a broad finance context.

4. Finance

Candidates should understand and be able to analyze financial statements including balance sheets, income statements, and statements of cash flow. Candidates should be able to calculate discounted cash flows, internal rate of return, present and future values of bonds, and apply the dividend growth model and price/earnings ratios concept to valuing stocks.

Candidates must be able to assess financial performance using net present value and the payback, discounted payback models, internal rate of return, and profitability index models. Candidates should be able to analyze statements and identify what should be discounted, what other factors should be considered, and the possible interactions between models.

Candidates should understand the trade-off between risk and return, the implications of the efficient market theory to the valuation of securities, and be able to perform the following:

- Apply measures of portfolio risk and analyze the effects of diversification, systematic and unsystematic risks. Calculate portfolio risk and analyze the impact of individual securities on portfolio risk
- Identify efficient portfolios and apply the CAPM to firm cost of capital measures
- Value cash flows and analyze the certainty equivalent versus risk-adjusted discount rates using assumptions for inflation, the term structure of interest rates, and default risk correctly in their calculations

Candidates should understand the following concepts and be able to use them to analyze financial structures:

- Efficient markets and their effect on security prices
- Capital structure and the impact of financial leverage and long- and short-term financing policies on capital structure
- Sources of capital and the definitions of techniques for valuing basic options such as calls and puts

Candidates should understand and be able to analyze financial performance by evaluating financial statements and financial ratios such as leverage, liquidity, profitability, market value ratios and analysis of accounting return versus economic return.

Candidates should understand and be able to apply the basic principles of option pricing theory including:

- Black-Scholes formula
- Valuation of basic options

Exam 3: Actuarial Models (CAS Only)

This examination develops the candidate's knowledge of the theoretical basis of actuarial models and the application of those models to insurance and other financial risks. A thorough knowledge of calculus, probability, and interest theory is assumed. Knowledge of risk management at the level of Exam 1 is also assumed.

The candidate will be required to understand, in an actuarial context, what is meant by the word "model," how and why models are used, and their advantages and their limitations. The candidate will be expected to understand what important results can be obtained from these models for the purpose of making business decisions, and what approaches can be used to determine these results.

1. Contingent Payment Models and Survival Models

Candidates should be able to work with discrete and continuous univariate probability distributions for failure time random variables. They will be expected to set up and solve equations in terms of life table functions, cumulative distribution functions, survival functions, probability density functions, and hazard functions (e.g., force of mortality), as appropriate. They should have similar facility with models of the joint distribution of two failure times (multiple lives) and the joint distribution of competing risks (multiple decrement). They should be able to formulate and apply stochastic and deterministic models for the present value of a set of future contingent cash flows under an assumed interest rate structure. Candidates also should be able to apply the equivalence principle, and other principles in the text, to associate a cost or pattern of (possibly contingent) costs with a set of future contingent cash flows.

- Create stochastic and deterministic models for present value, with an assumed interest rate structure, of a set of future contingent cash flows.
- Calculate the effects of changes to the components of the model.
- 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.
- 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.
- For discrete and continuous univariate probability distributions for failure time random variables, develop expressions in terms of the life table functions, lx, qx, px, nqx, npx, and m|nqx, for the cumulative distribution function, the survival function, the probability density function and the hazard function (force of mortality), and be able to:
  - 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
- Given the joint distribution of two failure times, be able to:
  - 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 Learning Objective A4, 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 Learning Objective A4 in the case in which the two failure times are independent

- Based on 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 lx(t), tqx(t), tpx(t), tdx(t), tmx(t) (t), be able to:
    - 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

2. Frequency and Severity Models

Candidates should be able to define frequency (counting) and severity distributions, and be able to use the parameters and moments of these distributions. Candidates also should be able to work with the families of distributions generated by algebraic manipulation and mixing of the basic distributions presented.

- For the following counting distribution (frequency distribution): Poisson, mixed Poisson, negative binomial, binomial, and the (a,b,1) class of distributions, be able to:
    - Describe the how changes in the parameters values impact the distribution
    - Calculate their moments
    - 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
- For the following families of loss (severity) distributions transformed beta, transformed gamma, inverse transformed gamma, lognormal and inverse Gaussian:
    - Describe how changes in the parameters values affect the distribution
    - Calculate their moments
    - 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
- Be able to interpret and produce graphical representations of loss and counting distributions. Be able to identify graphical presentations of loss that are:
    - Eliminated by a deductible
    - Covered under an insurance contract
    - Excess of the coverage provided by an insurance contract

3. Compound Distribution Models

Candidates should be able to calculate the probabilities associated with a compound distribution when the compounding distribution is one of the frequency distributions presented in the syllabus, and the compounded distribution is discrete or a discretization of a continuous distribution. Candidates also should be able to adjust such probability calculations for the impact of policy modifications such as deductibles, policy limits, and coinsurance.

- Describe a compound distribution.
- Calculate probabilities associated with a compound distribution when the compounding distribution is a member of the families in Learning Objective B1, and the compounded distribution is discrete or a discretization of a continuous distribution.
- Adjust the calculations described in Learning Objective C2 for the impact of policy modifications such as deductibles, policy limits and coinsurance.

4. Stochastic Process Models

Candidates should learn to solve problems using stochastic processes. They also should learn how to determine the probabilities and distributions associated with these processes. The following stochastic processes will be covered: Markov chain (discrete-time and continuous-time) processes, counting processes, Poisson process (including nonhomogeneous and compound Poisson processes), and Brownian motion.

- For stochastic process, describe a process and be able to distinguish between discrete-time and continuous-time processes.
- Describe 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.
- Describe a counting process.
- For a Poisson process be able to calculate:
  - The distribution of the waiting times between events
  - The distribution of the process increments
  - The behavior of the process over an infinitesimal time interval
- Describe a nonhomogeneous Poisson process. For this process, be able to calculate probabilities associated with numbers of events and time periods of interest.
- For a compound Poisson process:
  - Calculate moments associated with the value of the process at a given time
  - Describe the value of the process at a given time as a compound Poisson random variable

- Describe a Brownian motion process and be able to:
  - • 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
  - • Describe a Brownian motion process with drift and a geometric Brownian motion process

5. Ruin Models

Candidates should be able to analyze the probability of ruin using various models. Other topics covered in this section include the determination of the characteristics of the distribution of the amount of surplus (deficit) at the first time below the initial level and the impact of reinsurance. (Knowledge regarding reinsurance terminology is not assumed. Cash flows from reinsurance will be determinable based on the description of the reinsurance provided on the examination.)

For a ruin model:

- Describe the considerations included in a ruin model
- Calculate ruin probabilities for discrete time surplus processes

6. Simulation Modeling

Candidates should be able to generate discrete and continuous random variables using basic simulation methods. They also should be able to construct algorithms to simulate outcomes using stochastic models.

- Generate discrete and continuous random variables using basic simulation methods.
- Construct an algorithm to appropriately simulate outcomes under a wide variety of stochastic models.

Exam 4: Actuarial Modeling (Joint with SOA)

This examination provides an introduction to modeling and covers important actuarial and statistical methods that are useful in modeling. A thorough knowledge of calculus, linear algebra, probability, and mathematical statistics is assumed. 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:

- analyze data from an application in a business context
- determine a suitable model including parameter values
- 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 on Exam 3.

1. 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 perform the tasks listed below.

- Identify the steps in the modeling process and discuss how they interrelate.
- Identify the models and methods available, and understand the difference between the models and the methods.
- Explain the difference between a stochastic and a deterministic model and identify the advantages and disadvantages of each.
- Discuss the possible limitations imposed by the data available for input for constructing a model.
- Understand that all models presented in Exams 3 and 4 are closely related. Apply models from more than one family (e.g., regression, stochastic process, time series) to a particular business application.
- Identify the underlying assumptions implicit in each family of models and recognize which set(s) of assumptions are applicable to a given business application.
- 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.
- Obtain nonparametric estimates for a failure time or loss distribution using the empirical distribution, the Kaplan-Meier estimator, and the Nelson-Aalen estimator.
- Construct the likelihood model needed to estimate the parameters of a parametric failure time or loss distribution regression model.
- Construct the partial likelihood model needed to estimate the regression coefficients in a semiparametric failure time or loss distribution regression model.
- Adjust an estimation based on the presentation of the sample data—complete, incomplete, censored, truncated, grouped, shifted.
- Apply statistical tests to determine the acceptability of a fitted model:
  - Pearson's chi-square statistic
  - Likelihood ratio test
  - Kolmogorov-Smirnov statistic
- For estimators, define the terms: efficiency, bias, consistency, and mean squared error.

- 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.
- Test a given linear regression model's fit to a given data set.
- Assess the appropriateness of the linear regression model for a given data set by checking for such irregularities as heteroscedasticity, serial correlation, and multicollinearity.
- Develop deterministic forecasts from time series data, using simple extrapolation and moving average models, applying smoothing techniques and seasonal adjustment when appropriate.
- Use the concept of the autocorrelation function of a stochastic process to test the process for stationarity.
- Generate a forecast using the general ARIMA model and develop confidence intervals for the forecast.
- Test the hypothesis that a given stochastic process is a random walk.
- For an ARIMA process (including simpler models as special cases), estimate the model parameters, and perform appropriate diagnostic checks of the model.
- Apply limited fluctuation (classical) credibility including criteria for both full and partial credibility.
- Perform Bayesian analysis using discrete and continuous examples.
- Apply the Buhlmann-Straub credibility model to basic situations. Understand the relationship to the Bayesian model.
- Apply the conjugate prior in Bayesian analysis and Buhlmann-Straub credibility, and, in particular, to the Poisson-gamma model.
- Apply empirical Bayesian methods in the nonparametric and semiparametric cases.
- Compare and contrast the assumptions underlying limited fluctuation credibility, Bayesian analysis, and the Buhlmann-Straub credibility model.
- Determine an appropriate number of simulations to perform in order to estimate a quantity of interest.
- Quantify the variability of an estimate in the context of simulation.
- Determine the bootstrap estimates of the mean squared error of an estimator.
- Use basic simulation methods to validate a model.

2. 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.
- Risk classification