

IAA EDUCATION COMMITTEE

# Content Added to the Updated IAA Education Syllabus

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Prepared by the Syllabus Review Taskforce

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**8 July 2015**

This proposed updated Education Syllabus has been drafted by the Education Committee's Syllabus Review Taskforce. This document consists of (i) a narrative description of the broad changes that are proposed to the existing syllabus, (ii) a version of the draft syllabus presented to the Education Committee in Zurich 2015 with the learning objectives not covered by the existing syllabus highlighted with a different font.

# TABLE OF CONTENTS

<b>I. NEW SYLLABUS CONTENT</b> .....	Error! Bookmark not defined.
<b>II. UPDATED IAA EDUCATION SYLLABUS</b> .....	<b>4</b>
1 Mathematics .....	4
2 Assets .....	6
3 Data and Systems.....	7
4 Economics .....	9
5 Finance .....	11
6 Financial Systems .....	13
7 Models .....	14
8 Statistics .....	17
9 Risk Management .....	19
10 Personal and Professional Practice .....	21

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# I. NEW SYLLABUS CONTENT

## Introduction

This document illustrates the areas in the new draft syllabus that the Task Force considers are additions to the content of the existing syllabus. Such an assessment necessarily requires considerable judgement because the new syllabus adds detail to the existing high-level descriptions with the intention of giving more clarity and consistency to the way the syllabus is interpreted. The Task Force sees this as an important improvement to the current structure and based on the discussion in Zurich believes that this development is widely supported. The amount of new material that a Full Member Association will therefore have to bring in to its existing syllabus will depend on its previous interpretation of the current syllabus.

In the document below, we have classified learning objectives as follows:

- Material not explicitly in current syllabus but where knowledge is implied given other topics
- *Material not explicitly in current syllabus but set out as a focus in the current guidelines*
- Material that would generally be in current syllabuses although this will depend on the depth to which the current topic is covered
- **Material that is, in most cases, additional to the existing syllabus.**

Therefore, for most associations, the Task Force would expect that only topics in the last category will need to be added to the syllabus.

It is the intention of the Task Force that specialist knowledge is, where possible, removed from the syllabus. This is discussed in the Preamble to the published draft syllabus.

## Basis for inclusion of new content

The draft syllabus was based on the set of core competences agreed by the Education Committee at its meeting in London in September 2014. These are documented in the [Task Force report](#) to that meeting. There are three major areas of new content highlighted in the document below. These are discussed individually in this section.

## Mathematics

Mathematics was not explicitly included in the existing syllabus (except for mention of probability). This learning area includes topics which are needed as a foundation to be able to build competencies in other learning areas. Many of these topics could be covered as part of a student's

prior secondary and tertiary education. It will not be required of an association to ensure that these topics are formally covered, or assessed.

### **Data & Systems**

The growth in the demand for skills in predictive analytics, driven by developments and computer science and the explosion in the volumes of data available for analysis is having a major impact on the working lives of actuaries. The topics introduced in this area highlight the importance of modern analytical techniques and the need for actuaries to have skills in the use of computer packages for practical data analysis.

### **Personal & Professional Practice**

The existing syllabus includes professionalism but doesn't include personal and broader business competencies such as communication and decision making. It has long been recognized that these are vital competences for all qualified actuaries and a recommendation that communication is included in actuarial training is included in the Guidelines published with the current syllabus. The proposed syllabus explicitly includes these competencies.

### **Other new material**

There is a relatively small amount of new material in addition to the three areas described above. These have been included to ensure a newly qualified actuary has an understanding of the broader financial environment and also knowledge of up-to-date modelling techniques – particularly those based on simulation methods.

# II. UPDATED IAA EDUCATION SYLLABUS

## 1 MATHEMATICS

**Aim: To give students an adequate mathematical foundation to develop and apply the additional mathematical skills required for success in subsequent actuarial education.**

### *1.1 FUNCTIONS AND SETS [10%]*

- 1.1.1 Define a function and explain and apply functional concepts including: domain, codomain, image, limit, and inverse. (B3)
- 1.1.2 Determine asymptotes and turning points, and sketch a curve (B3)
- 1.1.3 Explain basic set terminology and apply basic set concepts (B3)
- 1.1.4 Define the supremum and infimum of a set of numbers (B1)
- 1.1.5 Apply simple numerical techniques to calculate roots of equations and evaluate integrals (C3)

### *1.2 DIFFERENTIATION [10%]*

- 1.2.1 Define the derivative of a function as a limit and determine the derivative from first principles (B3)
- 1.2.2 Apply the basic rules of differentiation (including the chain rule and implicit differentiation) to calculate first, higher-order, and partial derivatives (B3)
- 1.2.3 State the derivatives for power, trigonometric, inverse trigonometric, exponential, logarithmic, hyperbolic, and inverse hyperbolic functions (A1)
- 1.2.4 Determine the extreme points of a function of two variables, including using Lagrange multipliers for constrained problems (C3)

### *1.3 INTEGRATION [10%]*

- 1.3.1 Evaluate definite and indefinite integrals (anti-derivatives), using basic techniques including substitution and integration by parts (C3)
- 1.3.2 Evaluate double and triple integrals and calculate areas and volumes of simple geometric shapes (C3)
- 1.3.3 Interchange the order of integration of multiple integrals and change variables to evaluate multiple integrals (C3)
- 1.3.4 Apply simple numerical integration techniques such as the trapezium rule and Simpson's rule (C3)

### *1.4 SEQUENCES AND SERIES [10%]*

- 1.4.1 State the Taylor and Maclaurin expansions for functions of one and two variables (A1)
- 1.4.2 Define sequence and series and explain the concepts of boundedness, convergence, limit, and monotonicity (B1)
- 1.4.3 Use appropriate techniques to determine convergence or boundedness sequences and series in simple cases (B3)

### *1.5 DIFFERENTIAL EQUATIONS [8%]*

- 1.5.1 Solve first-order differential equations which are separable, linear or homogeneous (C3)
- 1.5.2 Solve simple first-order differential equation models for various applications with given conditions and use the solution to find the values of any parameters involved (C3)

### *1.6 REAL AND COMPLEX NUMBERS [2%]*

- 1.6.1 Carry out arithmetic with complex numbers (B2)

### *1.7 MATRICES AND SYSTEMS OF LINEAR EQUATIONS [20%]*

- 1.7.1 Carry out simple operations with matrices (addition, scalar multiplication, matrix multiplication, transposition) (C4)
- 1.7.2 Calculate the determinant of a matrix and use Cramer's rule to solve a system of linear equations (C3)
- 1.7.3 Use Gaussian elimination to find the rank of a matrix, to invert a matrix, and to solve systems of linear equations (C4)
- 1.7.4 Compute the characteristic polynomial of a matrix and determine its eigenvalues and eigenvectors (C4)
- 1.7.5 Determine whether a given matrix is diagonalizable and, if so, find a diagonalizing matrix (C4)

### *1.8 VECTORS, VECTOR SPACES AND INNER PRODUCT SPACES [5%]*

- 1.8.1 Carry out simple operations with vectors (addition, scalar product, vector product, scalar triple product) (C3)
- 1.8.2 Explain the concepts of vector space, inner product space, orthogonality (B2)

### *1.9 PROBABILITY [25%]*

- 1.9.1 Explain what is meant by a set function, a sample space for an experiment, and an event (B2)
- 1.9.2 Define probability as a set function on a collection of events, stating basic axioms (A1)
- 1.9.3 Derive basic properties satisfied by the probability of occurrence of an event, and calculate probabilities of events in simple situations (B2)
- 1.9.4 Derive the addition rule for the probability of the union of two events, and use the rule to calculate probabilities (B2)
- 1.9.5 Define the conditional probability of one event given the occurrence of another event, and calculate such probabilities (B3)
- 1.9.6 Derive Bayes' Theorem for events, and use the result to calculate probabilities (B3)
- 1.9.7 Define independence for two events, and calculate probabilities in situations involving independence (B3)

## 2 ASSETS

**Aim: To enable students to apply asset valuation techniques and investment theory to actuarial work.**

### *2.1 INVESTMENTS AND MARKETS [25%]*

- 2.1.1 Describe the characteristics of the main investment assets and of the markets in such assets (A1)
- 2.1.2 Describe the characteristics of the main derivative investments (including forwards, futures, options and swaps) and of the markets in such investments (A1)
- 2.1.3 Explain the principal economic influences on investment market price levels and total returns (B2)
- 2.1.4 Describe and explain the theoretical and historical relationships between the total returns and the components of total returns on the main asset classes and key economic variables (B2)

### *2.2 ASSET VALUATION [25%]*

- 2.2.1 Use the Capital Asset Pricing Model to calculate the required return on a particular asset, given appropriate inputs, and hence calculate the value of the asset (B3)
- 2.2.2 Use a multifactor model to calculate the required return on a particular asset, given appropriate inputs, and hence calculate the value of the asset (B3)
- 2.2.3 Explain the concepts of: efficient market, complete market, no-arbitrage, hedging (B2)
- 2.2.4 Explain the concepts underlying the risk-neutral and state price deflator approaches to valuing derivative securities and apply them in simple situations (B3)
- 2.2.5 Describe the properties of various stochastic models of the term structure of interest rates (B2)
- 2.2.6 Explain the limitations of the models described above and describe attempts to address them (B2)

### *2.3 PORTFOLIO MANAGEMENT [25%]*

- 2.3.1 Explain the principles and objectives of investment management and analyze the investment needs of an institutional or individual investor (B4)
- 2.3.2 Describe methods for the valuation of asset portfolios and explain their appropriateness in different situations (B2)
- 2.3.3 Explain how to use mean-variance portfolio theory to calculate an optimum portfolio and describe the limitations of this approach (B2)
- 2.3.4 Use mean-variance portfolio theory to calculate the expected return and risk of a portfolio of many risky assets, given appropriate inputs (B3)

### *2.4 INVESTMENT STRATEGY AND PERFORMANCE MEASUREMENT [25%]*

- 2.4.1 Explain how asset/liability modelling can be used to develop an appropriate investment strategy (B2)
- 2.4.2 Explain methods of quantifying the risk of investing in different classes and sub-classes of investment (B2)
- 2.4.3 Explain the use of a risk budget for controlling risks in a portfolio (B2)
- 2.4.4 Analyze the performance of an investment portfolio relative to a benchmark (B4)

# 3 DATA AND SYSTEMS

**Aim: To enable students to apply methods from statistics and computer science to real-world data sets in order to answer business and other questions.**

## 3.1 DATA AS A RESOURCE FOR PROBLEM SOLVING [30%]

- 3.1.1 Describe the possible aims of a data analysis (e.g. descriptive, inferential, predictive) (B2)
- 3.1.2 Describe the stages of conducting a data analysis to solve real-world problems in a scientific manner and describe tools suitable for each stage (C2)
- 3.1.3 Describe sources of data and explain the characteristics of different data sources, including extremely large data sets (B4)
- 3.1.4 Describe common data structures and data storage systems (A1)
- 3.1.5 Describe and explain measures of data quality (B2)
- 3.1.6 Use appropriate tools for cleaning, restructuring and transforming data to make it suitable for analysis (C3)

## 3.2 DATA ANALYSIS [30%]

- 3.2.1 Describe the purpose of exploratory data analysis (B2)
- 3.2.2 Use appropriate tools to calculate suitable summary statistics and undertake exploratory data visualizations (C4)
- 3.2.3 Use Principal Components Analysis to reduce the dimensionality of a complex data set (C4)
- 3.2.4 Use a computer package to fit a statistical distribution to a dataset and calculate appropriate goodness of fit measures (C4)
- 3.2.5 Use a computer package to fit a single or multiple linear regression models to a data set and interpret the output (C4)
- 3.2.6 Use a computer package to fit a survival model to a data set and interpret the output (C4)
- 3.2.7 Use a computer package to fit a generalized linear model to a data set and interpret the output (C4)

## 3.3 MACHINE LEARNING [20%]

- 3.3.1 Explain the meaning of the term *machine learning* and the difference between *supervised learning* and *unsupervised learning* (B2)
- 3.3.2 Explain when machine learning is an appropriate approach to problem solving and describe examples of the types of problems typically addressed by machine learning, explaining the difference between discrete and continuous approaches (B2)
- 3.3.3 Describe commonly used machine learning techniques in each of the four areas defined by the supervised/unsupervised and discrete/continuous splits (B2)
- 3.3.4 Use an appropriate computer package to apply neural network and decision tree techniques to simple machine learning problems (C3)

*3.4 PROFESSIONAL AND RISK MANAGEMENT ISSUES [10%]*

- 3.4.1 Explain the ethical and regulatory issues involved in working with personal data **and extremely large data sets (B2)**
- 3.4.2 **Explain the main issues to be addressed by a data governance policy and its importance for an organization. (B2)**
- 3.4.3 **Explain the risks associated with use of data (including algorithmic decision making) (B2)**

*3.5 VISUALIZING DATA AND REPORTING [10%]*

- 3.5.1 Create appropriate data visualizations to communicate the key conclusions of an analysis (C6)
- 3.5.2 **Explain the meaning and value of reproducible research and describe the elements required to ensure a data analysis is reproducible (B2)**

# 4 ECONOMICS

**Aim: To enable students to apply the core principles of microeconomics, macroeconomics and financial economics to actuarial work.**

## *4.1 MACROECONOMICS [30%]*

- 4.1.1 Explain basic macroeconomic measures (e.g. GDP) used to compare the economies of countries (B2)
- 4.1.2 Describe the structure of public finances for an industrialized country (A1)
- 4.1.3 Explain the effect of fiscal and monetary policy on the economy, including the effect on financial markets (B2)
- 4.1.4 Explain the role of international trade, exchange rates and the balance of payments in the economy (B2)
- 4.1.5 Explain the effect of savings and consumption rates on the economy (B2)
- 4.1.6 Explain the major factors affecting the level of interest rates, the rate of inflation, the exchange rate, the level of employment and the rate of growth for an industrialized country (B2)
- 4.1.7 Describe the function of money in the economy (B1)
- 4.1.8 Explain how interest rates are determined (B2)
- 4.1.9 Explain the relationship between money and interest rates (B2)
- 4.1.10 Explain how macroeconomic policies affect businesses (B2)

## *4.2 BUSINESS APPLICATIONS OF MICROECONOMICS [30%]*

- 4.2.1 Explain the concept of utility and how rational utility maximizing agencies make consumption choices (B2)
- 4.2.2 Explain the elasticity of supply and demand and the effects on a market of the different levels of elasticity (B2)
- 4.2.3 Explain the interaction between supply and demand and the way in which equilibrium market prices are achieved (B2)
- 4.2.4 Explain various pricing strategies that can be used by firms (B2)
- 4.2.5 Explain the core economic concepts involved in choices made by businesses with respect to short-run and long-run investment and production choices (B2)
- 4.2.6 Explain competitive markets and how they operate (B2)
- 4.2.7 Explain profitability in markets with imperfect competition (B2)
- 4.2.8 Explain the role of an entity's growth strategy on its profitability and security (B2)

### 4.3 FINANCIAL ECONOMICS [40%]

- 4.3.1 Evaluate the features of modern bond price models (B5)
- 4.3.2 Explain asset pricing models (e.g. Capital Asset Pricing Model) (B2)
- 4.3.3 Construct a yield curve (C3)
- 4.3.4 Explain the properties of single and multifactor models of asset returns (B2)
- 4.3.5 Explain the assumptions of mean-variance portfolio theory and its principle results (B2)
- 4.3.6 Explain the cash flow characteristics of various options (A2)
- 4.3.7 Explain the properties of the lognormal distribution and its applicability to option pricing (B2)
- 4.3.8 Explain the Black-Scholes formula (B2)
- 4.3.9 Calculate the value of European and American options (B3)
- 4.3.10 Simulate stock prices, including using variance reduction techniques (B3)**
- 4.3.11 Explain the calculation and use of option price partial derivatives (B2)
- 4.3.12 Explain how to control risk using delta-hedging (C3)
- 4.3.13 Explain the advantages and disadvantages of different measures of investment risk (e.g. Value at Risk, variance of return) (B2)
- 4.3.14 Explain the main findings of behavioral finance and how they can be applied to interpreting investor behavior (B4)

# 5 FINANCE

**Aim: To enable students to apply the core principles of financial theory, accounting, corporate finance and financial mathematics to actuarial work.**

## *5.1 FINANCIAL REPORTING AND TAXATION [20%]*

- 5.1.1 Describe the basic principles of personal and corporate taxation and the taxation of investments held by institutions (A1)
- 5.1.2 Explain why companies are required to produce annual reports and accounts (B2)
- 5.1.3 Explain fundamental accounting concepts and terms, and describe the main sources of accounting regulation (B2)
- 5.1.4 **Explain the value of reporting on environmental, social and economic sustainability and other alternatives to traditional financial reporting, and describe possible contents of such reports (B2)**
- 5.1.5 Explain the basic structure of company and group accounts (B2)
- 5.1.6 Explain the purpose of the main components of company accounts and interpret them (B4)
- 5.1.7 Construct simple statements of financial position and profit or loss (B6)
- 5.1.8 Calculate and interpret financial and accounting ratios (B4)

## *5.2 SECURITIES AND OTHER FORMS OF CORPORATE FINANCE [25%]*

- 5.2.1 Explain the characteristics of various forms of equity capital from the point of view of the issuer and the investor (B2)
- 5.2.2 Explain the characteristics of various forms of long term debt capital from the point of view of the issuer and the investor (B2)
- 5.2.3 Explain the characteristics of various forms of short and medium term finance from the point of view of the issuer and the investor (B2)
- 5.2.4 Describe the role of derivative securities and contracts in corporate finance (B1)
- 5.2.5 Describe the methods a company may use to raise capital through the issue of securities (A1)

## *5.3 FINANCIAL MATHEMATICS [30%]*

- 5.3.1 Calculate present and accumulated values of cash flows using deterministic interest rates (including rates compounding over different intervals and continuously) (B3)
- 5.3.2 Explain real and nominal interest rates and value inflation linked cash flows (B3)
- 5.3.3 Calculate the value of a futures contract (B3)
- 5.3.4 Explain the principle concepts and terms underlying the theory of a term structure of interest rates (B2)
- 5.3.5 Apply the term structure of interest rates to modelling various cash flows, including calculating the sensitivity of the value to changes in the term structure (B3)
- 5.3.6 Calculate expected present values and variances of cash flows using simple stochastic theory of interest (B3)

5.4 CORPORATE FINANCE [25%]

- 5.4.1 Describe different possible structures for a business entity and their advantages and disadvantages (B2)
- 5.4.2 Describe possible sources of finance for a business and explain the factors influencing choice of capital structure and dividend policy (B2)
- 5.4.3 **Explain capital budgeting and calculate cost of capital (B3)**
- 5.4.4 Calculate investment return on a project using different methods and evaluate each method (C5)

# 6 FINANCIAL SYSTEMS

**Aim: To give an overview of the financial environment in which most actuarial work is undertaken.**

## *6.1 ROLE AND STRUCTURE OF FINANCIAL SYSTEMS [30%]*

- 6.1.1 Describe the role and main forms of national and international financial markets (A1)
- 6.1.2 Describe the main forms of business organization (A1)
- 6.1.3 Describe the relationship between finance and the real resources and objectives of an organization (B1)
- 6.1.4 Describe the relationship between finance and the real resources and objectives of a nation (B1)
- 6.1.5 Describe the relationship between the stakeholders in an organization (including lenders and investors) (B1)
- 6.1.6 Describe agency theory and the theory of maximization of shareholder wealth (B1)

## *6.2 PARTICIPANTS IN FINANCIAL SYSTEMS [30%]*

- 6.2.1 Describe the main features of the following institutions and analyze their influence on the financial markets: national governments, central banks, investment exchanges, national and international financial bodies, national and international regulators (B4)
- 6.2.2 Describe the main participants in financial markets and explain their objectives and roles (examples include investment banks, retail banks, investment management companies, pension funds, insurance companies, non-financial corporations, sovereign funds, micro-finance providers, unregulated organizations) (B2)
- 6.2.3 Describe, in broad terms, typical operating models for the following institutions and explain how they allow the institutions to meet their objectives: insurance company, pension fund, retail bank, investment management company (C2)

## *6.3 FINANCIAL PRODUCTS [30%]*

- 6.3.1 Describe the main types of financial products and explain how they meet the objectives of issuers and purchasers (B2)

## *6.4 FACTORS AFFECTING FINANCIAL SYSTEM DEVELOPMENT AND STABILITY [10%]*

- 6.4.1 Describe major factors affecting the development of financial systems (including demographic changes, economic development, technological changes and climate change) (B1)
- 6.4.2 Describe the main risks to the stability of national and global financial systems (B1)

# 7 MODELS

**Aim: To enable students to apply stochastic processes and actuarial models to actuarial work.**

## *7.1 PRINCIPLES OF ACTUARIAL MODELLING. [20%]*

- 7.1.1 Describe why and how models are used including, in general terms, the use of models for pricing, reserving, and capital modelling. (C2)
- 7.1.2 Explain the benefits and limitations of modelling. (B2)
- 7.1.3 Explain the difference between a stochastic and a deterministic model, and identify the advantages/disadvantages of each. (B2)
- 7.1.4 Describe the characteristics of, and explain the use, of scenario-based and **proxy models**. (B2)
- 7.1.5 Describe, in general terms, how to decide whether a model is suitable for any particular application. (C2)
- 7.1.6 Explain the difference between the short-run and long-run properties of a model, and how this may be relevant in deciding whether a model is suitable for any particular application. (B2)
- 7.1.7 Describe, in general terms, how to analyze the potential output from a model, and explain why this is relevant to the choice of model. (B2)
- 7.1.8 Explain the desirable properties of a risk measure. (B2)
- 7.1.9 Calculate risk measures, including Value at Risk and Tail Value at Risk, and explain their properties, uses and limitations. (B3)
- 7.1.10 Describe the process of sensitivity testing of assumptions and explain why this forms an important part of the modelling process. (C2)
- 7.1.11 Produce an audit trail enabling detailed checking and high-level scrutiny of a model. (C6)
- 7.1.12 Explain the factors that must be considered when communicating the results following the application of a model and produce appropriate documentation. (C6)

## *7.2 FUNDAMENTALS OF SEVERITY MODELS [10%]*

- 7.2.1 Recognize classes of distributions, including extreme value distributions, suitable for modelling the distribution of severity of loss and their relationships. (B4)
- 7.2.2 Apply the following techniques for creating new distributions: multiplication by a constant, raising to a power, exponentiation, mixing. (B3)
- 7.2.3 Calculate various measures of tail weight and interpret the results to compare the tail weights. (B5)

## *7.3 FUNDAMENTALS OF FREQUENCY MODELS [10%]*

- 7.3.1 Explain the characteristics of distributions suitable for modeling frequency of losses, for example: Poisson, mixed Poisson, binomial, negative binomial, and geometric distributions. (B2)
- 7.3.2 Identify applications for which each distribution may be used; explain the reasons why; and apply the distribution to the application, given the parameters. (B3)

#### *7.4 FUNDAMENTALS OF AGGREGATE MODELS [10%]*

- 7.4.1 Compute relevant moments, probabilities and other distributional quantities for collective risk models. (B3)
- 7.4.2 Compute aggregate claims distributions and use them to calculate loss probabilities. (B3)
- 7.4.3 Evaluate the effect of coverage modifications (deductibles, limits and coinsurance) and inflation on aggregate models. (B3)

#### *7.5 SURVIVAL MODELS [10%]*

- 7.5.1 Apply multiple state Markov chain and Markov process models. (B3)
- 7.5.2 Derive maximum likelihood estimators for the transition intensities in models of transfers between states with piecewise constant transition intensities. (B3)
- 7.5.3 Explain the concepts of survival models. (B2)
- 7.5.4 Calculate and interpret standard probability functions including survival and mortality probabilities, force of mortality, and complete and curtate expectation of life. (B3)
- 7.5.5 For models dealing with multiple lives and/or multiple states, explain the random variables associated with the model; calculate and interpret marginal and conditional probabilities, and moments. (B3)
- 7.5.6 Describe the principal forms of heterogeneity within a population and the ways in which selection can occur. (B2)

#### *7.6 ACTUARIAL APPLICATIONS [30%]*

- 7.6.1 Define simple contracts for contingent payments dependent on the state of a single entity (for example life insurance or annuity benefits) on the occurrence of a particular event; develop and evaluate formulae for the means and variances of the present values of the payments under these contracts, assuming constant deterministic interest. (B3)
- 7.6.2 Apply survival models to simple problems in long-term insurance, pensions and banking such as calculating the premiums and reserves for a life insurance contract, and the potential defaults on a book of loans for a bank. (B3)
- 7.6.3 Define simple contracts for contingent payments dependent on the state of multiple entities; develop and evaluate formulae for the means of the present values of the payments under these contracts, assuming constant deterministic interest. (B3)
- 7.6.4 Describe and apply methods of projecting and valuing expected cash flows that are contingent upon multiple decrement events. (B3)
- 7.6.5 Describe and apply projected cash flow techniques in pricing, reserving, and assessing profitability of contracts for contingent payments with appropriate allowance for expenses (including life insurance and pension fund applications) (B3)
- 7.6.6 Describe and apply techniques for analyzing a delay (or run-off) triangle and projecting the ultimate position. (B3)

*7.7 CAPITAL AND ECONOMIC MODELLING [10%]*

- 7.7.1 Explain why financial institutions need capital and describe different capital measures, including regulatory capital and economic capital. (B2)
- 7.7.2 **Describe the process of capital modelling. (C2)**
- 7.7.3 Describe different methods of risk aggregation and explain their relative advantages and disadvantages. (B2)
- 7.7.4 Describe and apply the main concepts underlying the analysis of time series models. (B3)

# 8 STATISTICS

**Aim: To enable students to apply core statistical techniques to actuarial problems.**

## *8.1 RANDOM VARIABLES [20%]*

- 8.1.1 Explain the concepts of random variable, probability distribution, distribution function, expected value, variance and higher moments. (B2)
- 8.1.2 Calculate expected values and probabilities associated with the distributions of random variables. (B3)
- 8.1.3 Define a probability generating function, a moment generating function, a cumulant generating function and cumulants, derive them in simple cases, and use them to evaluate moments. (B3)
- 8.1.4 Define basic discrete and continuous distributions and be able to apply them. (B3)
- 8.1.5 Explain the concepts of independence, jointly distributed random variables and conditional distributions, and use generating functions to establish the distribution of linear combinations of independent random variables. (B3)
- 8.1.6 Explain and apply the concepts of conditional expectation and compound distribution. (B3)

## *8.2 STATISTICAL INFERENCE [20%]*

- 8.2.1 State and apply the central limit theorem. (B3)
- 8.2.2 Explain the concepts of random sampling, statistical inference and sampling distribution, and state and use basic sampling distributions. (B3)
- 8.2.3 Describe the main methods of estimation and the main properties of estimators, and apply them. (B3)
- 8.2.4 Construct confidence intervals for unknown parameters. (C3)
- 8.2.5 Test hypotheses. (C3)
- 8.2.6 Estimate empirical survival and loss distributions, for example using:
  - a) Kaplan-Meier estimator, including approximations for large data sets
  - b) Nelson Aalen estimator
  - c) Cox proportional hazards
  - d) **Kernel density estimators (C3)**
- 8.2.7 Estimate transition intensities depending on age, exactly or using large sample approximations. (C3)

## *8.3 REGRESSION [20%]*

- 8.3.1 Explain linear relationships between variables using correlation analysis and regression analysis. (B2)
- 8.3.2 Explain the fundamental concepts of a generalized linear model (GLM), and describe how a GLM may be applied. (B3)
- 8.3.3 Estimate parameters for these models and perform diagnostic tests including checking assumptions and evaluating model fit. (B5)

*8.4 BAYESIAN STATISTICS AND CREDIBILITY THEORY [20%]*

- 8.4.1 Explain the fundamental concepts of Bayesian statistics and apply them to parameter estimation, hypothesis testing, and model selection. (B3)
- 8.4.2 Explain and apply Bayesian and empirical Bayesian credibility models. (B3)
- 8.4.3 Explain and apply limited fluctuation credibility. (B3)

*8.5 SIMULATION [20%]*

- 8.5.1 Explain the concepts of Monte Carlo simulation. (B2)
- 8.5.2 Simulate both discrete and continuous random variables using the inversion method. (C3)
- 8.5.3 Estimate the number of simulations needed to obtain an estimate with a given error and a given degree of confidence. (B3)
- 8.5.4 **Use simulation to determine the p-value for a hypothesis test. (C3)**
- 8.5.5 **Use the bootstrap method to estimate the mean squared error of an estimator. (C3)**

# 9 RISK MANAGEMENT

**Aim: To enable students to apply core aspects of enterprise risk management to the analysis of risk management issues faced by an entity, and to recommend appropriate solutions.**

## 9.1 THE RISK ENVIRONMENT [10%]

- 9.1.1 Explain the concepts of the actuarial control cycle. (B2)
- 9.1.2 Explain the concept of enterprise risk management (ERM). (B2)
- 9.1.3 Describe aspects of the operating environment relevant to the ERM process:
  - a) the legislative and regulatory environment
  - b) financial and investment markets
  - c) sustainability and environmental factors
  - d) the operating sector of the organization, including demand for particular products and services (A1)
- 9.1.4 Define risk appetite and explain the importance of attitudes towards risk of key stakeholders. (A2)
- 9.1.5 Describe the elements of a robust ERM framework for an organization. (A1)

## 9.2 RISK IDENTIFICATION [25%]

- 9.2.1 Describe and classify different types of risk including: financial risks, insurance risks, environmental risk, operational risk and business risk. (B2)
- 9.2.2 Explain how the design of different products and services affects the risk exposure of the parties to a transaction and analyze the exposures for a particular transaction. (B4)
- 9.2.3 Explain how the characteristics of the parties to a transaction affects the nature of the risk borne by each and analyze the exposures for a particular transaction. (B4)
- 9.2.4 Explain the purpose of risk classification. (B2)
- 9.2.5 Explain the concept of risk pooling and the portfolio approach to the overall management of risks. (B2)

## 9.3 RISK MEASUREMENT AND MODELLING [25%]

- 9.3.1 Explain the use of models for risk management in the context of:
  - a) Pricing
  - b) Reserving
  - c) Valuation
  - d) Capital managementincluding appropriate allowance for expenses (B2)
- 9.3.2 Explain the principles and process of setting assumptions for model inputs. (C2)

#### 9.4 RISK MITIGATION AND MANAGEMENT [20%]

9.4.1 Explain the most common risk mitigation and management techniques:

- a) Avoidance
- b) Acceptance
- c) Reduction
- d) Transfer
- e) Monitoring (C2)

9.4.2 Describe the principles of asset / liability management and apply them to the main types of liability held by financial institutions. (C3)

9.4.3 **Analyze the risk management aspects of a particular business issue and recommend an appropriate risk management strategy. (C6)**

9.4.4 **Explain the implication of risk for capital requirement, including economic and regulatory capital requirements. (B2)**

#### 9.5 RISK MONITORING AND COMMUNICATION [20%]

9.5.1 Explain how data collection and analysis for monitoring risk experience depends on the other stages of the control cycle and produce a data collection plan for a given risk profile. (C6)

9.5.2 Explain the use of experience monitoring to revise models and assumptions and improve future risk management. (C2)

9.5.3 Describe risk measures and explain the importance of risk reporting to managers and stakeholders. (B2)

# 10 PERSONAL AND PROFESSIONAL PRACTICE

**Aim: To require use of enabling skills and professional requirements to improve students' actuarial work products.**

## 10.1 EFFECTIVE COMMUNICATIONS [30%]

- 10.1.1 Explain common techniques used to produce effective written and oral communications (B2).
- 10.1.2 Produce effective technical communications for a work project for an audience of peers, managers or clients (B6).
- 10.1.3 Produce a comprehensive summary of technical actuarial results (B6).
- 10.1.4 Produce a comprehensive work report for a regulator (B4).
- 10.1.5 Produce an effective executive summary for an actuarial work product (B6).
- 10.1.6 Produce a summary of conclusions following completion of a peer review of another actuary's work (B5).
- 10.1.7 Deliver an understandable oral presentation with visual aids on an actuarial subject to a non-actuarial audience (B6).
- 10.1.8 Create a plan to communicate actuarial work results to a relevant audience that could be made up of peers, managers, executives, clients or the public (C6).
- 10.1.9 Evaluate a problem by questioning client to ensure work project is understood well enough to proceed (B5).
- 10.1.10 Evaluate whether a particular solution has been effectively communicated to an audience (B5).
- 10.1.11 Evaluate whether the uncertainty of a solution has been appropriately communicated (B5).
- 10.1.12 Create appropriate permanent documentation for a work product (A6).
- 10.1.13 Evaluate whether a communication plan was effective in delivery (C5).

## 10.2 PROBLEM SOLVING AND DECISION MAKING [20%]

- 10.2.1 Apply the actuarial control cycle appropriately (C3).
- 10.2.2 Evaluate whether all material factors have been considered when designing a solution (A4).
- 10.2.3 Analyze and prioritize stakeholder needs when designing a solution (A5).
- 10.2.4 Evaluate whether current team's actuarial skills are sufficient to complete the work assignment well (C5).
- 10.2.5 Distinguish material factors from other factors (e.g. material external forces from other external forces) (A5).
- 10.2.6 Explain the purpose of a strategy and how it relates to competitive advantage (B2).
- 10.2.7 Explain the elements of an effective decision-making process (C2).
- 10.2.8 Explain how an entity's culture and structure affect decision-making processes (B2).
- 10.2.9 Evaluate the effectiveness of a particular decision-making process (C5).
- 10.2.10 Explain the benefits of teamwork and time management (C2).
- 10.2.11 Use common project management techniques to implement a work plan (B6).

### *10.3 PROFESSIONAL STANDARDS [20%]*

- 10.3.1 Explain the elements of a profession (A2).
- 10.3.2 Explain the role of professional standards and ethics in an actuary's work (A2).
- 10.3.3 Explain how the profession's discipline process applies to a member (A2).
- 10.3.4 Explain the requirements the profession's standards of practice impose on a work assignment (C2).
- 10.3.5 Explain the structure and governance of the student's actuarial association (A2).
- 10.3.6 Explain the actuary's obligations to clients, regulators and the public (D2).
- 10.3.7 Explain the need to select professional responsibility over personal gain and to prioritize public interest. (C2)

### *10.4 PROFESSIONALISM IN PRACTICE [30%]*

- 10.4.1 Explain typical situations that can lead to professional misconduct (A2).
- 10.4.2 Explain the importance of documenting work and the elements of acceptable documentation (A2).
- 10.4.3 Explain the need to use peer review and checking of work (A2).
- 10.4.4 Apply professional standards and ethics appropriately in a case study (B5).
- 10.4.5 Describe how to monitor changes to professional standards and standards of practice (A1).
- 10.4.6 Describe how to monitor own compliance with professional obligations (D1).
- 10.4.7 Produce a continuing professional development plan to ensure actuarial skills are maintained and developed (D6).
- 10.4.8 Evaluate current level of own professional development and personal limitations upon accepting a particular actuarial work assignment (D5).
- 10.4.9 Evaluate the effectiveness of a personal professional development plan (D5).**