IAA EDUCATION COMMITTEE

Updated IAA Education Syllabus

Prepared by the Syllabus Review Taskforce

For approval by electronic vote

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This proposed updated Education Syllabus has been drafted by the Education Committee's Syllabus Review Taskforce. This document consists of (i) a preamble that provides the background and reasoning for the proposed updated education syllabus, (ii) the updated education syllabus itself that contains 9 learning areas divided into (a) Supporting Learning Areas and (b) Core Learning Areas.

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I. PREAMBLE

1. INTRODUCTION

The goals of the IAA include the maintenance of a basic education syllabus, which is a requirement in terms of the Full Member Association (FMA) accreditation process. One of the accreditation requirements as a FMA is that:

> *"The Full Member shall require all of its actuaries who are recognized as having attained fully qualified actuarial status on or after January 1, 2006 to successfully complete an education programme compliant with the Education Guidelines and Education Syllabus, as adopted by Council from time to time."*[1]

The Education Syllabus sets out the *minimum* requirements for a Fully Qualified Actuary (FQA) in accordance with the IAA regulations. All Full Member Associations are required to have an education syllabus that meets the minimum education syllabus. This syllabus should be the minimum foundation necessary to ensure that FMAs are in fact professional actuarial associations, and not merely trade associations; as well as having a common core competence among actuaries.

The intention of the IAA education syllabus is to prepare actuaries to operate in a wide variety of professional environments, including insurance companies, health organizations, pension plans, risk management, government, regulatory regimes and other fields. Actuaries need to have a detailed understanding of economic, financial, demographic and insurance risks and expertise in developing and using statistical and financial models to inform financial decisions as well as for pricing, establishing the amount of liabilities and setting capital requirements for uncertain future events. A detailed understanding of these risks requires a solid mathematical knowledge and analytical competence. A strong technical toolkit, specifically the ability to model and understand risk, backed with the professional promise, will allow the profession to thrive and grow globally.

The new education syllabus therefore focuses on models and techniques that can be applied across a number of practice areas. While there is a requirement for students to understand the main financial security systems and apply these techniques to problems within these systems, detailed specialist knowledge is not a part of this minimum requirement syllabus.

Actuaries work in almost all regions of the world. Therefore, it is necessary – when defining minimum requirements – to find common standards for actuaries in developed economies as well as developing countries. Actuarial specializations may be developed at a regional or local level to meet the requirements for actuaries in specific economies. In this respect, the IAA acknowledges that there needs to be a fair degree of flexibility in accommodating different approaches in interpreting, teaching and assessing the syllabus.

Following continued development of the actuarial profession, together with the introduction of new methods and technologies, some topics (e.g. commutation functions for life contingencies) have now been omitted from the compulsory syllabus. The application of survival models, however, has been retained, as these models are useful in a number of practice areas. It should be noted that Full Member Associations have flexibility to include topics in their syllabuses that are not covered in the IAA minimum syllabus.

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[1] IAA Internal Regulations 2.2.2 (d)

Finally, this syllabus only refers to initial education. Professionals are expected to be in a process of lifelong learning and therefore continuing professional development is essential.

2. Classification of Learning Objectives

The updated Education Syllabus sets out the depth of knowledge and application required using the Model of Learning Objectives created by Rex Heer, Iowa State University. This Model is based on Bloom's Taxonomy of Education Objectives (1956) and Anderson and Krathwohl's 2001 revision.

The Model of Learning Objectives uses both a *knowledge dimension* and a *cognitive process dimension* as demonstrated in the graphic below.

Revised Bloom's Taxonomy (RBT)

Cognitive Process Dimension

Knowledge Dimension

Verbs → / Objects ↓	1. **REMEMBER** Recognize, Recall	2. **UNDERSTAND** Interpret, Exemplify, Classify, Summarize, Infer, Compare, Explain	3. **APPLY** Execute, Implement	4. **ANALYZE** Differentiate, Organize, Attribute	5. **EVALUATE** Check, Critique	6. **CREATE** Generate, Plan, Produce
A. Factual Knowledge	A1	A2	A3	A4	A5	A6
B. Conceptual Knowledge	B1	B2	B3	B4	B5	B6
C. Procedural Knowledge	C1	C2	C3	C4	C5	C6
D. Metacognitive Knowledge	D1	D2	D3	D4	D5	D6

Adopting this Model of Learning Objectives allows us to define both the areas of learning achievement expected of future actuaries and also the specific level and type of knowledge required. This framework is widely used and provides Full Member Associations a way of linking the required learning objectives with appropriate learning activities and assessments.

The model uses four types of knowledge – Factual, Conceptual, Procedural and Metacognitive – and six cognitive processes – Remember, Understand, Apply, Analyze, Evaluate and Create.

1. **Factual** knowledge generally involves terminology associated with actuarial work and specific details with respect to financial security systems, actuarial models, actuarial methods and the external forces important to actuarial work. Factual knowledge also includes specific details with respect to membership in the actuarial profession.
2. **Conceptual** knowledge generally involves the interrelationships among current or potential future financial security systems, common actuarial models, common actuarial methods, external forces and the actuary.
3. **Procedural** knowledge involves how an actuary actually does something. To demonstrate Procedural Knowledge often requires both Factual and Conceptual knowledge. Many practical skills require Procedural knowledge.

4. **Metacognitive** knowledge involves an actuary's awareness of his/her strengths and weaknesses, including when the actuary is not qualified to do specific work. This knowledge will also include an actuary's awareness of personal learning needs and lifetime learning strategy. Some normative skills involve acquiring metacognitive knowledge (e.g. self-knowledge).

The six categories of the cognitive process include nineteen specific cognitive processes that clarify the scope of the six categories. There is a natural order for cognitive processes from the lowest order thinking skills "Remember", through "Understand", "Apply", "Analyze" and "Evaluate" to the highest cognitive order "Create". The order does not mean to imply difficulty in succeeding at the cognitive level but rather that the lower cognitive process will be subsumed by another higher cognitive process. For example, you would often need to "Remember" to "Create".

3. MATHEMATICAL BACKGROUND

The mathematical foundation for anyone entering the actuarial profession is very important, as many topics require a deep knowledge of a number of mathematical techniques. The Appendix to the syllabus lists an absolute minimum mathematical background required to commence actuarial studies. However, more in-depth mathematical studies are implicit in the requirement to demonstrate an understanding of the models and techniques covered by the syllabus and will be necessary in structuring an actuarial program.

4. LEARNING AREAS

The syllabus is divided into nine learning areas, which can be further subdivided into five Supporting Learning Areas and four Core Learning Areas.

i) Supporting Learning Areas

These areas cover a number of topics which form an important foundation for all actuaries around the world. These topics can generally be covered in courses taught by non-actuarial specialists, although they can also be usefully taught in a specialist actuarial course. In this respect, the IAA acknowledges that there will need to be some flexibility in the depth and nature of topics covered, and one would expect substantial, rather than complete, coverage, and some tailoring towards local needs.

It is expected that at least 80% of the objectives in each Core Learning Area will be fully covered at the Bloom's level indicated. The objectives covered should be chosen so that the overall Bloom's level is close to the overall level of the full set of objectives for the Learning Area. Initially, some Full Member Associations may need to work towards this level; while they are doing so a minimum coverage of 70% of the objectives will be acceptable.

ii) Core Learning Areas

These cover areas which the IAA believes are core to the actuary operating effectively. These topics would generally be taught in a specialist actuarial course, and one would expect materially complete coverage by each association, while still allowing for some flexibility.

It is expected that at least 90% of the objectives in each Core Learning Area will be fully covered at the Bloom's level indicated. The objectives covered should be chosen so that the overall Bloom's level is close to the overall level of the full set of objectives for the Learning Area. Initially, some Full Member Associations may need to work towards this level; while they are doing so a minimum coverage of 80% of the objectives will be acceptable.

Within each of these areas, there are a number of high-level subdivisions. The intention of these divisions is for ease of presentation and topics can be mixed and matched using different combinations. Integration across learning areas by combining learning objectives from different areas into one course/assessment is desirable. For example, students learning the modelling process (Learning Area "Actuarial Models") are more likely to gain a deeper understanding if they not only do the modelling but also communicate, in writing or by a presentation (Learning Area "Personal and Actuarial Professional Practice") their understanding of what they have done, why they have done it and what it means. Teaching and learning methods that focus on integration of learning objectives (especially technical knowledge and professional practice skills) are particularly relevant to educating capable actuaries. One such approach is Problem Based Learning.

Each Leaning Area subdivision has a number of related learning objectives, using the Revised Bloom's Taxonomy as a framework to set out the type of knowledge required and the cognitive level to be achieved. Within a subdivision, or even a specific learning objective, more than one type of knowledge or skill and more than one cognitive process category may be covered.

5. SPECIALIZATION

As noted above, the intention of the IAA syllabus is to provide a minimum foundation for actuaries to operate in a number of specialized areas – these would include traditional areas such as Pensions or Insurance, and newer areas such as Banking or Enterprise Risk Management. The syllabus excludes specialist topics in any of these areas as the IAA sees these specializations as additional to the basic actuarial education set out in these minimum requirements and further training and experience should be required for an actuary to play roles that may be reserved for them as part of legislation in some countries. Some national association might see the need to include a specialization into their requirements to become FQA to fulfill the expectation of an actuary in their own environment.

Full Member Associations may also define additional education processes (e.g. CERA for Enterprise Risk Management specialization). In addition, for effective coverage of the core areas of the syllabus, practical context is essential and this may require more in-depth coverage of one or more area of specialization.

6. ASSESSMENT

Assessment is a critical element of any education process. It is the means of determining whether, and how well, students are able to demonstrate the desired learning outcomes. To most students, assessment *IS* the curriculum.

No specific forms of assessment have been assumed in the syllabus. However, it is very important that the nature of assessment takes into account the specific syllabus objectives and linkage to the syllabus objective classification set out above. The following guidelines should therefore be noted:

- The underlying principle of assessment should be to ensure that students exhibit competency for the underlying syllabus objective.

- The traditional unseen examination may remain a key part of assessments. Focus should always be on ensuring students understand and apply the techniques. A mixture of multiple choice questions, short questions and long questions may be appropriate, with the understanding that objectives associated with the higher-order verbs (4,5,6) would be best tested with long questions.

- Assessment structures should encourage ongoing learning as a means to encourage long-term assimilation of actuarial competencies. Therefore, classwork may form an appropriate portion of assessment, as long there is an assurance that assessment is based on a student's own work.

- Some topics, particularly in Learning Area "Data and Systems", may lend themselves to computer-based project work as a useful form of assessment. This would be encouraged, with the proviso that there is appropriate security to ensure that students only submit their own work.

- Many topics in the "Personal and Actuarial Professional Practice" Learning Area would not normally be able to be assessed via a formal examination. However, some forms of assessment, such as a student presenting on a topic may be very useful in assessing both technical understanding and related competencies in this learning area. Attainment of some of these skills could be assessed during delivery of a course by recording a student's attendance and active participation. Attainment of other skills in this learning area could be certified by a supervising actuary, since the skills will often be learned and demonstrated in a work environment.

7. DELIVERY

As with assessment, there is no prescription on how actuarial education will be delivered. The expectation would be that the education system of a Full Member Association can be delivered, as has been case in the past, by:

(i) The Full Member Association directly
(ii) Tertiary educational bodies or other suitable external providers
(iii) The education system of another Full Member Association
(iv) A combination of the above.

The Full Member Association will need to be satisfied, however, that the education system covers all of the topics in the syllabus and candidate achievement in these topics is appropriately assessed.

II. UPDATED IAA EDUCATION SYLLABUS

A. Supporting Learning Areas

1. STATISTICS

Aim: To enable students to apply core statistical techniques to actuarial applications in insurance, pensions and emerging areas of actuarial practice.

1.1 RANDOM VARIABLES

1.1.1 Explain the concepts of random variable, probability distribution, distribution function, expected value, variance and higher moments. (B2)

1.1.2 Calculate expected values and probabilities associated with the distributions of random variables. (B3)

1.1.3 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)

1.1.4 Define basic discrete and continuous distributions and be able to apply them. (B3)

1.1.5 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)

1.1.6 Explain and apply the concepts of conditional expectation and compound distribution. (B3)

1.2 STATISTICAL INFERENCE

1.2.1 State and apply the central limit theorem. (B3)

1.2.2 Explain the concepts of random sampling, statistical inference and sampling distribution, and state and use basic sampling distributions. (B3)

1.2.3 Describe the main methods of estimation and the main properties of estimators, and apply them. (B3)

1.2.4 Construct confidence intervals for unknown parameters. (C3)

1.2.5 Test hypotheses. (C3)

1.2.6 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)

1.2.7 Estimate transition intensities depending on age, exactly or using large sample approximations. (C3)

1.3 Regression

1.3.1 Explain linear relationships between variables using correlation analysis and regression analysis. (B2)

1.3.2 Explain the fundamental concepts of a generalized linear model (GLM), and describe how a GLM may be applied. (B3)

1.3.3 Estimate parameters for these models and perform diagnostic tests including checking assumptions and evaluating model fit. (B5)

1.4 Bayesian statistics and credibility theory

1.4.1 Explain the fundamental concepts of Bayesian statistics and apply them to parameter estimation, hypothesis testing, and model selection. (B3)

1.4.2 Explain and apply Bayesian and empirical Bayesian credibility models. (B3)

1.5 Stochastic processes and time series

1.5.1 Describe and apply the main concepts underlying stochastic processes. (B3)

1.5.2 Describe and apply the main concepts underlying time series models. (B3)

1.6 Simulation

1.6.1 Explain the concepts of Monte Carlo simulation. (B2)

1.6.2 Simulate both discrete and continuous random variables using the inversion method. (C3)

1.6.3 Estimate the number of simulations needed to obtain an estimate with a given error and a given degree of confidence. (B3)

1.6.4 Use a permutation test to determine the distribution of a test statistic. (C3)

1.6.5 Use the bootstrap method to estimate properties (e.g. the mean squared error) of an estimator. (C3)

2. ECONOMICS

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

2.1 MACROECONOMICS

2.1.1 Explain basic macroeconomic measures (e.g. GDP) used to compare the economies of countries. (B2)
2.1.2 Describe the structure of public finances for an industrialized country. (A1)
2.1.3 Explain the effect of fiscal and monetary policy on the economy, including the effect on financial markets. (B2)
2.1.4 Explain the role of international trade, exchange rates and the balance of payments in the economy. (B2)
2.1.5 Explain the effect of savings and consumption rates on the economy. (B2)
2.1.6 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)
2.1.7 Describe the function of money in the economy. (B1)
2.1.8 Explain how interest rates are determined. (B2)
2.1.9 Explain the relationship between money and interest rates. (B2)
2.1.10 Explain how macroeconomic policies affect businesses. (B2)

2.2 MICROECONOMICS

2.2.1 Explain the concept of utility and how rational utility maximizing agencies make consumption choices. (B2)
2.2.2 Explain the elasticity of supply and demand and the effects on a market of the different levels of elasticity. (B2)
2.2.3 Explain the interaction between supply and demand and the way in which equilibrium market prices are achieved. (B2)
2.2.4 Explain various pricing strategies that can be used by firms. (B2)
2.2.5 Explain the core economic concepts involved in choices made by businesses with respect to short-run and long-run investment and production choices. (B2)
2.2.6 Explain competitive markets and how they operate. (B2)
2.2.7 Explain profitability in markets with imperfect competition. (B2)

2.3 Financial Economics

2.3.1 Evaluate the features of bond price models. (B5)
2.3.2 Explain asset pricing models (e.g. Capital Asset Pricing Model). (B2)
2.3.3 Explain how market data can be used to construct a yield curve. (B2)
2.3.4 Explain the properties of single and multifactor models of asset returns. (B2)
2.3.5 Explain the assumptions of mean-variance portfolio theory and its principal results. (B2)
2.3.6 Explain the cash flow characteristics of various options. (A2)
2.3.7 Explain the properties of the lognormal distribution and its applicability to option pricing. (B2)
2.3.8 Explain the Black-Scholes formula. (B2)
2.3.9 Calculate the value of European and American put and call options. (B3)
2.3.10 Simulate stock prices, including using variance reduction techniques. (B3)
2.3.11 Explain the calculation and use of option price partial derivatives. (B2)
2.3.12 Explain how to control risk using delta-hedging. (C3)
2.3.13 Explain the advantages and disadvantages of different measures of investment risk (e.g. Value at Risk, variance of return). (B2)
2.3.14 Explain the main findings of behavioral finance and how they can be applied. (B4)

3. FINANCE

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

3.1 FINANCIAL REPORTING AND TAXATION

3.1.1 Describe the basic principles of personal and corporate taxation and the taxation of investments held by institutions. (A1)

3.1.2 Explain why companies are required to produce annual reports and accounts. (B2)

3.1.3 Explain fundamental accounting concepts and terms, and describe the main sources of accounting regulation. (B2)

3.1.4 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)

3.1.5 Explain the basic structure of company and group accounts. (B2)

3.1.6 Explain the purpose of the main components of company accounts and interpret them. (B4)

3.1.7 Construct simple statements of financial position and profit or loss. (B6)

3.1.8 Calculate and interpret financial and accounting ratios. (B4)

3.2 SECURITIES AND OTHER FORMS OF CORPORATE FINANCE

3.2.1 Explain the characteristics of various forms of equity capital from the point of view of the issuer and the investor. (B2)

3.2.2 Explain the characteristics of various forms of long-term debt capital from the point of view of the issuer and the investor. (B2)

3.2.3 Explain the characteristics of various forms of short and medium term finance from the point of view of the issuer and the investor. (B2)

3.2.4 Describe the role of derivative securities and contracts in corporate finance. (B1)

3.2.5 Describe the methods a company may use to raise capital through the issue of securities. (A1)

3.3 FINANCIAL MATHEMATICS

3.3.1 Calculate present and accumulated values of cash flows using deterministic interest rates (including rates compounding over different intervals and continuously). (B3)

3.3.2 Explain real and nominal interest rates and value inflation linked cash flows. (B3)

3.3.3 Calculate the value of a forward contract. (B3)

3.3.4 Explain the principal concepts and terms underlying the theory of a term structure of interest rates. (B2)

3.3.5 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)

3.3.6 Explain how duration and convexity are used in the immunization of a portfolio of liabilities. (B2)

3.3.7 Calculate expected present values and variances of cash flows using simple stochastic theory of interest. (B3)

3.4 CORPORATE FINANCE

3.4.1 Describe different possible structures for a business entity and their advantages and disadvantages. (B2)

3.4.2 Describe possible sources of finance for a business and explain the factors influencing choice of capital structure and dividend policy. (B2)

3.4.3 Explain capital budgeting and calculate cost of capital. (B3)

3.4.4 Calculate investment return on a project using different methods and evaluate each method. (C5)

4. Financial Systems

Aim: To enable students to understand the financial environment in which most actuarial work is undertaken, and key products and principles of insurance, pensions and other areas of traditional and emerging actuarial practice.

4.1 Role and structure of financial systems

4.1.1 Describe the role and main forms of national and international financial markets. (A1)

4.1.2 Explain the relationship between finance and the real resources and objectives of an organization. (B2)

4.1.3 Explain the relationship between finance and the real resources and objectives of a nation. (B2)

4.1.4 Describe the role of private and personal interests in decision making in government and private institutions, and explain agency theory and prohibitions of conflicts of interest and duty. (B2)

4.2 Participants in financial systems

4.2.1 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)

4.2.2 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 and re-insurance companies, non-financial corporations, sovereign funds, micro-finance providers, unregulated organizations). (B2)

4.2.3 Describe typical operating and corporate governance models for the following institutions and explain how they allow the institutions to meet their objectives: insurance company, re-insurance company, pension fund, retail bank, investment management company. (C2)

4.3 Financial products and benefits

4.3.1 Describe the main types of social security benefits and financial products and explain how they meet the objectives of issuers and beneficiaries. (B2)

4.3.2 Explain the main principles of insurance and pensions that impact on these benefits and products. (B2)

4.4 Factors affecting financial system development and stability

4.4.1 Describe major factors affecting the development of financial systems (including demographic changes, economic development, technological changes and climate change). (B1)

4.4.2 Explain the main elements and purpose of prudential and market regulation. (B2)

4.4.3 Explain the main risks to the stability of national and global financial systems. (B2)

5. ASSETS

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

5.1 INVESTMENTS AND MARKETS

5.1.1 Describe the characteristics of the main investment assets and of the markets in such assets. (A1)

5.1.2 Describe the characteristics of the main derivative investments (including forwards, futures, options and swaps) and of the markets in such investments. (A1)

5.1.3 Explain the principal economic influences on investment market price levels and total returns. (B2)

5.1.4 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)

5.2 ASSET VALUATION

5.2.1 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)

5.2.2 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)

5.2.3 Explain the concepts of: efficient market, complete market, no-arbitrage, hedging. (B2)

5.2.4 Explain the concepts underlying the risk-neutral or state price deflator approaches to valuing derivative securities and apply them in simple situations. (B3)

5.2.5 Describe the properties of various stochastic models of the term structure of interest rates. (B2)

5.2.6 Explain the limitations of the models described above and describe attempts to address them. (B2)

5.3 PORTFOLIO MANAGEMENT

5.3.1 Explain the principles and objectives of investment management and analyze the investment needs of an institutional or individual investor. (B4)

5.3.2 Describe methods for the valuation of asset portfolios and explain their appropriateness in different situations. (B2)

5.3.3 Use mean-variance portfolio theory to calculate an optimum portfolio and describe the limitations of this approach. (B3)

5.3.4 Use mean-variance portfolio theory to calculate the expected return and risk of a portfolio of many risky assets, given appropriate inputs. (B3)

5.4 INVESTMENT STRATEGY AND PERFORMANCE MEASUREMENT

5.4.1 Explain how asset/liability modelling can be used to develop an appropriate investment strategy. (B2)

5.4.2 Explain methods of quantifying the risk of investing in different classes and sub-classes of investment. (B2)

5.4.3 Explain the use of a risk budget for controlling risks in a portfolio. (B2)

5.4.4 Analyze the performance of an investment portfolio relative to a benchmark. (B4)

B. Core Learning Areas

6. 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, in particular with application to questions in long and short term insurance, social security, retirement benefits, healthcare and investment.

6.1 Data as a resource for problem solving

6.1.1 Describe the possible aims of a data analysis (e.g. descriptive, inferential, predictive). (B2)

6.1.2 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)

6.1.3 Describe sources of data and explain the characteristics of different data sources, including extremely large data sets. (B4)

6.1.4 Describe common data structures and data storage systems. (A1)

6.1.5 Describe and explain measures of data quality. (B2)

6.1.6 Use appropriate tools for cleaning, restructuring and transforming data to make it suitable for analysis. (C3)

6.2 Data analysis

6.2.1 Describe the purpose of exploratory data analysis. (B2)

6.2.2 Use appropriate tools to calculate suitable summary statistics and undertake exploratory data visualizations. (C4)

6.2.3 Use Principal Components Analysis to reduce the dimensionality of a complex data set. (C4)

6.2.4 Use a computer package to fit a statistical distribution to a dataset and calculate appropriate goodness of fit measures. (C4)

6.2.5 Use a computer package to fit a single or multiple linear regression model to a data set and interpret the output. (C4)

6.2.6 Use a computer package to fit a survival model to a data set and interpret the output. (C4)

6.2.7 Use a computer package to fit a generalized linear model to a data set and interpret the output. (C4)

6.3 Statistical Learning

6.3.1 Explain the meaning of the terms *statistical learning* and *machine learning* and the difference between *supervised learning* and *unsupervised learning.* (B2)

6.3.2 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)

6.3.3 Describe commonly used machine learning techniques in each of the four areas defined by the supervised/unsupervised and discrete/continuous splits. (B2)

6.3.4 Use an appropriate computer package to apply neural network and decision tree techniques to simple machine learning problems. (C3)

6.4 PROFESSIONAL AND RISK MANAGEMENT ISSUES

6.4.1 Explain the ethical and regulatory issues involved in working with personal data and extremely large data sets. (B2)

6.4.2 Explain the main issues to be addressed by a data governance policy and its importance for an organization. (B2)

6.4.3 Explain the risks associated with use of data (including algorithmic decision making). (B2)

6.5 VISUALIZING DATA AND REPORTING

6.5.1 Create appropriate data visualizations to communicate the key conclusions of an analysis. (C6)

6.5.2 Explain the meaning and value of reproducible research and describe the elements required to ensure a data analysis is reproducible. (B2)

7. ACTUARIAL MODELS

Aim: To enable students to apply stochastic processes and actuarial models to actuarial work, in particular to applications in long and short term insurance, social security, retirement benefits, healthcare and investment.

7.1 PRINCIPLES OF ACTUARIAL MODELLING

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 and analyze realistic examples. (B4)

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 Carry out sensitivity and stress testing of assumptions and explain why this forms an important part of the modelling process. (C3)

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

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

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

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

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 multiple 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

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 state and multiple decrement events, and apply these contracts to insurance and pension problems. (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, short term insurance and pension fund applications). (B3)

7.6.6 Describe and apply techniques for analysing a delay (or run-off) triangle and projecting the ultimate position. (B3)

8. ACTUARIAL RISK MANAGEMENT

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

8.1 THE RISK ENVIRONMENT

8.1.1 Apply the concepts of the actuarial control cycle to the risk management process. (B3)

8.1.2 Explain the concept of enterprise risk management (ERM). (B2)

8.1.3 Analyze aspects of the operating environment and their relevance 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. (B4)

8.1.4 Explain why financial institutions need capital and describe different capital measures, including regulatory capital and economic capital. (B2)

8.1.5 Define risk appetite and risk culture explain the importance of attitudes towards risk of key stakeholders. (B2)

8.1.6 Evaluate the elements of an ERM framework for an organization. (C5)

8.2 RISK IDENTIFICATION

8.2.1 Describe and classify different types of risk including: financial risk, insurance risk, environmental risk, operational risk and business risk. (B2)

8.2.2 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)

8.2.3 Explain how the characteristics of the parties to a transaction affect the nature of the risk borne by each and analyze the exposures for a particular transaction. (B4)

8.2.4 Explain the purpose of risk classification. (B2)

8.2.5 Explain the difference between risk (measurable) and uncertainty (immeasurable). (B2)

8.2.6 Explain the concept of risk pooling and the portfolio approach to the overall management of risks. (B2)

8.3 RISK MEASUREMENT AND MODELLING

8.3.1 Explain the use of models for risk management in the context of:

a) Pricing
b) Reserving
c) Valuation
d) Capital management

including appropriate allowance for expenses. (B2)

8.3.2 Explain the principles and process of setting assumptions for model inputs. (C2)

8.3.3 Describe different methods of risk aggregation and explain their relative advantages and disadvantages. (B2)

8.3.4 Apply these models to practical problems in insurance, pensions or an emerging area of actuarial practice. (C5)

8.4 RISK MITIGATION AND MANAGEMENT

8.4.1 Explain the most common risk mitigation and management techniques:

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

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

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

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

8.5 RISK MONITORING AND COMMUNICATION

8.5.1 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)

8.5.2 Explain the use of experience monitoring and apply the results of a monitoring exercise to revise models and assumptions and improve future risk management. (C3)

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

9. Personal and Actuarial Professional Practice

Aim: To enable students to apply their technical knowledge and skills in an effective, practical and professional manner.

9.1 Effective Communications

9.1.1 Explain common techniques used to produce effective written and oral communications. (B2)
9.1.2 Produce effective technical communications for a work project for an audience of peers, managers or clients. (B6)
9.1.3 Produce a comprehensive summary of technical actuarial results. (B6)
9.1.4 Produce an effective executive summary for an actuarial work product. (B6)
9.1.5 Explain matters to be addressed in a summary of conclusions following a peer review of another actuary's work. (B2)
9.1.6 Evaluate a problem in consultation with a manager to ensure work project is understood well enough to proceed. (B4)
9.1.7 Explain the importance of ensuring, where relevant, that the uncertainty surrounding a solution has been effectively communicated. (B2)
9.1.8 Create appropriate permanent documentation for a work product. (A6)

9.2 Problem Solving and Decision Making

9.2.1 Apply the actuarial control cycle appropriately. (C3)
9.2.2 Evaluate whether all material factors have been considered when designing a solution. (A4)
9.2.3 Analyze and prioritize stakeholder needs when designing a solution. (A5)
9.2.4 Distinguish material factors from other factors (e.g. material external forces from other external forces). (A5)
9.2.5 Understand the purpose of a strategy and how it relates to competitive advantage. (B2)
9.2.6 Explain the elements of an effective decision-making process. (C2)
9.2.7 Apply a decision-making process to a particular case study. (B4)
9.2.8 Explain the benefits of teamwork and time management. (C2)
9.2.9 Explain the factors to consider when deciding whether to escalate a project decision to a higher level of management. (D2)
9.2.10 Use common project management techniques to design a work plan. (C6)

9.3 Professional Standards

9.3.1 Explain the distinguishing features of a profession. (A2)
9.3.2 Understand the importance of professional standards (code of conduct, qualification standards, standards of practice, etc.) and ethics in an actuary's work. (A2)
9.3.3 Explain the need for a discipline process for a profession (A2).
9.3.4 Understand the circumstances which could give rise to a charge of professional misconduct and how the association's discipline process could apply to such a case. (A2)
9.3.5 Explain how association's standards of practice may affect a work assignment. (C2)

9.3.6 Explain the structure and governance of the student's actuarial association and the role of the actuarial association. (A2)

9.3.7 Explain the actuary's obligations to clients, regulators, other stakeholders and the wider public. (D2)

9.3.8 Explain the need to prioritize professional responsibility and public interest over personal gain with respect to a work assignment. (C2)

9.4 Professionalism in Practice

9.4.1 Analyze typical situations that could lead to an accusation of professional misconduct and identify actions which could be taken to avoid misconduct. (A5)

9.4.2 Analyze situations where an actuary's integrity could come under pressure and develop a plan for handling the situation successfully. (A5)

9.4.3 Explain the importance of documenting work and the elements of acceptable documentation to achieve a satisfactory audit trail. (A2)

9.4.4 Understand the importance of checking work and the need to consider peer review. (A2)

9.4.5 Apply professional standards and ethics appropriately to a situation outlined in a case study. (B5)

9.4.6 Describe how to monitor changes to standards of practice and how to determine which statements apply to a particular work assignment. (D1)

9.4.7 Understand how to determine which standards apply, and are paramount, when an assignment may be governed by professional standards of more than one actuarial organization. (A2)

9.4.8 Evaluate current level of own professional development and personal limitations to accept a particular actuarial work assignment. (D5)

Appendix

Foundation Mathematics

Aim: To enable students to develop an adequate foundation upon which to build the additional mathematical skills required for successful actuarial practice.

1 FUNCTIONS AND SETS

1.1 Define a function and explain and apply functional concepts including: domain, codomain, image, limit, and inverse.
1.1 Determine asymptotes and turning points, and sketch a curve.
1.2 Explain basic set terminology and apply basic set concepts.
1.3 Define the supremum and infimum of a set of numbers.
1.4 Apply simple numerical techniques to calculate roots of equations and evaluate integrals.

2 DIFFERENTIATION

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

3 INTEGRATION

3.1 Evaluate definite and indefinite integrals, using basic techniques including substitution and integration by parts.
3.2 Evaluate double and triple integrals and calculate areas and volumes of simple geometric shapes.
3.3 Interchange the order of integration of multiple integrals and change variables to evaluate multiple integrals.
3.4 Apply simple numerical integration techniques such as the trapezium rule and Simpson's rule.

4 SEQUENCES AND SERIES

4.1 State the Taylor and Maclaurin expansions for functions of one and two variables.
4.2 Define sequence and series and explain the concepts of boundedness, convergence, limit, and monotonicity.
4.3 Use the formulae for the sums of arithmetic and geometric progressions.
4.4 Use appropriate techniques to determine convergence or boundedness sequences and series in simple cases.

5 DIFFERENTIAL EQUATIONS

5.1 Solve first-order differential equations which are separable, linear or homogeneous.

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.

6 REAL AND COMPLEX NUMBERS

6.1 Carry out arithmetic with complex numbers.

7 MATRICES AND SYSTEMS OF LINEAR EQUATIONS

7.1 Carry out simple operations with matrices (addition, scalar multiplication, matrix multiplication, transposition).

7.2 Calculate the determinant of a matrix and use Cramer's rule to solve a system of linear equations.

7.3 Use Gaussian elimination to find the rank of a matrix, to invert a matrix, and to solve systems of linear equations.

7.4 Compute the characteristic polynomial of a matrix and determine its eigenvalues and eigenvectors.

7.5 Determine whether a given matrix is diagonalizable and, if so, find a diagonalizing matrix.

8 VECTORS, VECTOR SPACES AND INNER PRODUCT SPACES

8.1 Carry out simple operations with vectors (addition, scalar product, vector product, scalar triple product).

8.2 Explain the concepts of vector space, inner product space, orthogonality.

9 PROBABILITY

9.1 Explain what is meant by a set function, a sample space for an experiment, and an event.

9.2 Define probability as a set function on a collection of events, stating basic axioms.

9.3 Derive basic properties satisfied by the probability of occurrence of an event, and calculate probabilities of events in simple situations.

9.4 Derive the addition rule for the probability of the union of two events, and use the rule to calculate probabilities.

9.5 Define the conditional probability of one event given the occurrence of another event, and calculate such probabilities.

9.6 Derive Bayes' Theorem for events, and use the result to calculate probabilities.

9.7 Define correlation and independence for two events, and calculate probabilities in situations involving independence.