MA319 Probability and Statistics for Actuarial Science

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	C	15 (7.5)	90% Exam, 10% Coursework	Villa Dr C

Contact Hours

48, consisting of lectures, classes and computer sessions

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of this module students will:
a) have gained an understanding of the basic concepts of probability and statistics;
b) have established a framework of core statistical material relevant to their degree programme, and which is also appropriate for later statistics modules students may need to study as part of their degree;
c) be proficient in the main statistical ideas and techniques introduced in the course;
d) have some appreciation of ways of examining data, both at the exploratory stage through graphical representations and numerical summaries, and more formally through techniques of statistical inference;
e) be able to handle and analyse data using the statistical package MINITAB;
f) have some appreciation of how statistics is used in practice.
g) have an appreciation of how the statistical procedures covered are derived and their validity

The intended generic learning outcomes
Students who successfully complete this module will:
a) have begun to develop a logical, mathematical approach to solving problems;
b) have enhanced their ability to work with relatively little guidance;
c) have gained organisational and study skills;
d) be able to use information technology for data analysis and presentation.
On successful completion of the module, students will also have improved their key skills in written communication, numeracy, computing and problem solving.

Method of Assessment

Examination (90%) and coursework (10%)

Preliminary Reading

GM Clarke & D Cooke: A Basic Course in Statistics (5th ed. Arnold, 2004) (B)
S Ross: A First Course in Probability (4th ed. Prentice Hall, 1994)
J Crawshaw & J Chambers: A Concise Course in A-Level Statistics, with Worked Examples (3rd ed. Stanley Thornes, 1994)
DV Lindley & WF Scott: New Cambridge Elementary Statistical Tables (2nd ed. C.U.P., 1995) (E)

Pre-requisites

The core Mathematics modules. This module is also a prerequisite for second year Statistics and Actuarial Science modules, and in particular for MA629.

Synopsis *

This module will introduce the basic concepts of probability and statistics, with applications to a variety of topics illustrated with real data. The techniques that are discussed can be used in their own right to solve simple problems, but also serve as an important foundation for later, more advanced, modules. After dealing with key ideas in probability theory, the module will cover descriptive statistics, before moving on to statistical inference - the science of drawing conclusions from data. A brief introduction to statistical computing will be included. Outline syllabus includes: Concepts and axioms of probability; marginal, conditional and joint probabilities; Bayes' theorem; discrete and continuous random variables; expectation; common distributions; numerical summaries of data; sampling distributions; point estimation; interval estimation and hypothesis tests; association between variables; goodness of fit.

Marks on this module can count towards exemption from the professional examination CT3 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA501 Statistics for Insurance

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	I	15 (7.5)	100% Exam	Wang Dr X
1	Canterbury	Spring	I	15 (7.5)	90% Exam, 10% Coursework	Wang Dr X

Contact Hours

32 lectures, 3 example classes (1 hour each)

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of the module students will be able to:
- explain basic concepts and models in decision analysis and statistics, as presented in the module, and apply them in insurance;
- construct risk models appropriate to short term insurance contracts and make the relevant inference;
- describe and apply the fundamental concepts of creditbility theory;
- describe and apply the basic methodology used in rating general insurance business;
- describe and apply techniques for analysing a delay (or run-off) triangle;

The Intended Generic Learning Outcomes. One successful completion of the module, students will:
- be able to demonstrate probabilistic and statistical skills in solving financial problems;
- have enhanced their conceptual skills and logical reasoning abaility;
- demonstrate a broad understanding of the range of application of statistics to financial processes.

Method of Assessment

90% Examination, 10% Coursework

Preliminary Reading

The students are provided with the study notes published by the Actuarial Education Company and a copy of "Formulae and Tables for Examinations".

The following book is also relevant:
PJ Boland Statistical and Probabilistic Methods in Actuarial Science (Chapman & Hall, 2007) (R)

Pre-requisites

MA629 Probability and Inference or MA529 Probability and Statistics for Actuarial Science 2

Synopsis *

This module covers aspects of Statistics which are particularly relevant to insurance. Some topics (such as risk theory and credibility theory) have been developed specifically for actuarial use. Other areas (such as Bayesian Statistics) have been developed in other contexts but now find applications in actuarial fields. Stochastic processes of events such as accidents, together with the financial flow of their payouts underpin much of the work. Since the earliest games of chance, the probability of ruin has been a topic of interest. Outline Syllabus includes: Decision Theory; Bayesian Statistics; Loss Distributions; Reinsurance; Credibility Theory; Empirical Bayes Credibility theory; Risk Models; Ruin Theory; Generalised Linear Models; Run-off Triangles.

Marks on this module can count towards exemption from the professional examination CT6 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA516 Contingencies 1

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	I	15 (7.5)	80% Exam, 20% Coursework	Wood Mr N

Contact Hours

48 hours of Lectures and Examples classes.

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a) Define simple assurance and annuity contracts, and develop formulae for the means and variances of the present values of the payments under these contracts, assuming constant deterministic interest.
b) Obtain expressions in the form of sums/integrals for the mean and variance of the present value of benefit payments under each contract above including cases where premiums are payable more frequently than annually and that benefits may be payable annually or more frequently than annually.
c) Describe practical methods of evaluating expected values and variances of the simple contracts defined in objective a.
d) Describe and calculate, using ultimate or select mortality, net premiums and net premium provisions of simple insurance contracts.
e) Carry out the above for simple insurance contracts involving two lives.

The intended generic learning outcomes. On successful completion of the module students will:

a) have developed a logical mathematical approach to solving problems;
b) have developed skills in written communication, time management and organisation and studying.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The study notes published by the Actuarial Education Company are recommended. Instructions on how to obtain the notes will be given in class.

The following may be consulted for background reading, but are not required reading.
NL Bowers, HU Gerber, JC Hickman et al. Actuarial mathematics. 2nd ed. Society of Actuaries, 1997. ISBN: 0938959468
WF Scott Life assurance mathematics, Heriot-Watt University, 1999.
Neill, A. Heinemann Life contingencies., 1977. ISBN: 0434914401
HU Gerber Life insurance mathematics. 3rd ed. Springer; Swiss Association of Actuaries, 1997. ISBN: 354062242X

Pre-requisites

MA315 Financial Mathematics, MA319 Probability & Statistics for Actuarial Science, or equivalent.

Synopsis *

This module introduces the concept of survival models, which model future survival time as a random variable. The concept is combined with the financial mathematics learned in module MA315, making it possible to analyse simple contracts which depend on survival time, such as life insurance and annuities. The syllabus will cover: introduction to survival models including actuarial notation, allowance for temporary initial selection and an overview of the typical pattern of human mortality; formulae for the means and variances of the present values of payments under life insurance and annuity contracts assuming constant deterministic interest; practical methods for evaluating the formulae; description and calculation of net premiums, net premium provisions and mortality profit or loss under simple life insurance and annuity contracts; and extension of the basic concepts to straightforward contracts involving two lives.

Marks on this module can count towards examption from the professional examination CT5 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA525 Survival Models II

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	McQuire Mr P

Contact Hours

36 hours comprising lectures and group work on exercises.

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of this module students will be able to:
a) describe the principles of actuarial modelling;
b) describe non-parametric estimation procedures for the lifetime distribution, including censoring, the Kaplan-Meier estimate, Nelson-Aalen estimate and Cox regression model (proportional hazards model);
c) derive maximum likelihood estimators (and hence estimates) for the transition intensities in models of transfers between states with piecewise constant transition intensities;
d) describe the Binomial and Poisson models of mortality, deriving maximum likelihood estimators for the probability/force of mortality and compare with the Markov model;
e) describe how to estimate transition intensities depending on age, exactly or using the census approximation, including calculation of exposed to risk and specification of census formulae based on various age definitions;
f) describe and carry out tests for the consistency of crude estimates with a standard table or a set of graduated estimates;
g) describe the process of graduation and the advantages and disadvantages of the various methods.

The intended generic learning outcomes
Students who successfully complete this module will have further developed:
a) a logical mathematical approach to solving problems;
b) skills in oral and written communication;
c) time management and organisation skills;
d) studying.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

BSc students are recommended to purchase the relevant study notes published by the Actuarial Education Company. Arrangements will be made for students to purchase these directly from the publisher at a discount price.

Pre-requisites

MA516 Contingencies I

Restrictions

Synopsis *

Calculations in life assurance, pensions and health insurance require reliable estimates of transition intensities/survival rates. This module covers the estimation of these intensities and the graduation of these estimates so they can be used reliably by insurance companies and pension schemes. The syllabus includes the following: Principles of actuarial modelling. Distribution and density functions of the random future lifetime, the survival function and the force of hazard. Estimation procedures for lifetime distributions including censoring, Kaplan-Meier estimate, Nelson-Aalen estimate and Cox model. Statistical models of transfers between states. Maximum likelihood estimators for the transition intensities. Binomial and Poisson models of mortality. Estimation of age-dependent transition intensities. The graduation process. Testing of graduations. Measuring the exposed-to-risk.

Marks on this module can count towards examption from the professional examination CT4 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA529 Probability and Statistics for Actuarial Science 2

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	I	15 (7.5)	90% Exam, 10% Coursework	Wang Dr X

Contact Hours

approximately 36 scheduled lecture hours; plus 6 workshops.

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students:
a) will have a reasonable knowledge of probability theory and of the key ideas of statistical inference, in particular to enable them to study further statistics modules at levels I and H (for which this module is a pre-requisite);
b) will have a reasonable ability to use mathematical techniques to manipulate joint, marginal and conditional probability distributions, and to derive distributions of transformed random variables;
c) will have a reasonable ability to use mathematical techniques to calculate point and interval estimates of parameters and to perform tests of hypotheses;
d) will have some appreciation of the relevance of mathematical statistics to real world problems.

The intended generic learning outcomes. On successful completion of the module, students:
a) will have developed their understanding of probability and statistics;
b) will have applied a range of mathematical techniques to solve statistical problems;
c) will have developed their ability to abstract the essentials of problems and to formulate them mathematically;
d) will have improved their key skills in numeracy and problem solving;
e) will have enhanced their study skills and ability to work with relatively little supervision.

Method of Assessment

90% by a 2-hour written examination at the end of the year and 10% coursework.

Preliminary Reading

Students are provided with study notes published be the Actuarial Education Company.
I Miller & M Miller John E Freund's Mathematical Statistics with Applications, 8th ed. Pearson Education, 2012 (QA276) (R)

RV Hogg, JW McKean & AT Craig Introduction to Mathematical Statistics, 7th ed. Boston, Pearson, 2013 (QA276) (B)
HJ Larson Introduction to Probability Theory and Statistical Inference. 3rd ed. Wiley, 1982 (HA29) (B)

Synopsis *

This module is a pre-requisite for many of the other statistics modules at Stages 2, 3 and 4, but it can equally well be studied as a module in its own right, extending the ideas of probability and statistics met at Stage 1 and providing practice with the mathematical skills learned in MA321. Marks on this module can count towards exemption from the professional examination CT3 of the Institute and Faculty of Actuaries. It starts by revising the idea of a probability distribution for one or more random variables, and then looks at different methods to derive the distribution of a function of random variables. These techniques are then used to prove some of the results underpinning the hypothesis test and confidence interval calculations met at Stage 1, such as for the t-test or the F-test. With these tools to hand, the module moves on to look at how to fit models (probability distributions) to sets of data. A standard technique, known as the method of maximum likelihood, is introduced, which is then used to fit the model to the data to obtain point estimates of the model parameters and to construct hypothesis tests and confidence intervals for these parameters. Linear regression and analysis of variance models are introduced, which aim to describe the relationship between a random variable of interest and one or more covariates, for example the relationship between income and education level or gender. Outline Syllabus includes: Joint, marginal and conditional distributions of discrete and continuous random variables; Generating functions; Transformations of random variables; Poisson processes; Sampling distributions; Point and interval estimation; Properties of estimators; Maximum likelihood; Hypothesis testing; Neyman-Pearson lemma; Maximum likelihood ratio test; Simple linear regression: ANOVA.

Marks on this module can count towards exemption from the professional examination CT3 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA533 Contingencies 2

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	Millett Mr J

Contact Hours

36 hours combined Lectures and Example Classes

Learning Outcomes

On successful completion of the module students will be able to:
a) Describe the calculation, using ultimate or select mortality, of net premiums and net premium reserves for increasing and decreasing benefits and annuities.
b) Describe the calculation of gross premiums and reserves of assurance and annuity contracts.
c) Describe methods which can be used to model cashflows contingent upon competing risks.
d) Describe the technique of discounted emerging costs, for use in pricing, reserving, andassessing profitability.
e) Describe the principal forms of heterogeneity within a population and the ways in which selection can occur.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The study notes published by the Actuarial Education Company are recommended. Instructions on how to obtain these notes will be given in class.

Pre-requisites

MA516 Contingencies I

Synopsis *

Life Contingencies is concerned with the probabilities of life and death. Its practical application requires a considerable sophistication in mathematical techniques to ensure the soundness of many of the biggest financial institutions – life assurance companies and pension funds. This module introduces the actuarial mathematics which is needed for this. The aim of this module (together with MA516 – Contingencies 1) is to provide a grounding in the mathematical techniques which can be used to model and value cash flows dependent on death, survival, or other uncertain risks and cover the application of these techniques to calculate premium rates for annuities and assurances on one or more lives and the reserves that should be held for these contracts. Outline syllabus includes variable benefits and with profits contracts; gross premiums and reserves for fixed and variable benefit contracts; competing risks; pension funds; profit testing and reserves; mortality, selection and standardisation. This module together with module MA516 cover the entire syllabus of the UK Actuarial Profession's subject CT5 – Contingencies.

MA537 Mathematics of Financial Derivatives

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	Tapadar Dr P

Contact Hours

36

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:

a. Demonstrate a knowledge and understanding of the properties of option prices, valuation methods and hedging techniques.
b. Demonstrate a knowledge and understanding of models of the term structure of interest rates.
c. Demonstrate a knowledge and understanding of models for credit risk and solve problems using these models.
d. Appreciate recent developments in Financial Economics and the links between the theory of Financial Economics and their practical application

The intended generic learning outcomes. On successful completion of the Module, students will have developed a logical mathematical approach to solving problems. They will have developed skills in written communication, time management and organisation and studying.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Hull, John, Options, futures and other derivatives, 7th Edition, Prentice Hall.
Baxter, Martin; Rennie, Andrew, Financial calculus : an introduction to derivative pricing, Cambridge University Press, 1996
The study notes published by the Actuarial Education Company are recommended. Instructions on how to obtain these notes will be given in class.

Pre-requisites

MA529 Probability and Statistics for Actuarial Science 2 or MA629 Probability and Inference

Synopsis *

This module introduces the main features of basic financial derivative contracts and develops pricing techniques. Principle of no-arbitrage, or absence of risk-free arbitrage opportunities, is applied to determine prices of derivative contracts, within the framework of binomial tree and geometric Brownian motion models. The interplay between pricing and hedging strategies, along with risk management principles, are emphasized to explain the mechanisms behind derivative instruments. Models of interest rate and credit risk are also discussed in this context. Outline syllabus includes: An introduction to derivatives, binomial tree model, Black-Scholes option pricing formula, Greeks and derivative risk management, interest rate models, credit risk models.

Marks on this module can count towards exemption from the professional examination CT8 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA539 Financial Modelling

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	100% Coursework	Millett Mr J

Contact Hours

36 (computer classes with some lecture-based content).

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the Module, students will be able to:
a) demonstrate skills in specific actuarial software and information technology (e.g.
PROPHET)
b) understand the principles of specific actuarial mathematics techniques
c) develop simple actuarial computer models to solve actuarial problems
d) interpret and communicate the results of the models derived in b).

The intended generic learning outcomes. On successful completion of the Module, students will have developed a logical mathematical approach to solving problems. They will have developed skills in oral and written communication and developed the relevant computing skills.

Method of Assessment

- PROPHET: two coursework tests each counting 25% towards the final module mark
- Spreadsheet financial modelling: one coursework assessment counting 50% towards the final module mark

Pre-requisites

Co-requisites: MA533 Contingencies II

Synopsis *

This module is split into two parts: 1. An introduction to the practical experience of working with the financial software package, PROPHET, which is used by commercial companies worldwide for profit testing, valuation and model office work. The syllabus includes: overview of the uses and applications of PROPHET, introduction on how to use the software, setting up and performing a profit test for a product , analysing and checking the cash flow results obtained for reasonableness, using the edit facility on input files, performing sensitivity tests , creating a new product using an empty workspace by selecting the appropriate indicators and variables for that product and setting up the various input files, debugging errors in the setting up of the new product, performing a profit test for the new product and analysing the results. 2. An introduction to financial modelling techniques on spreadsheets which will focus on documenting the process of model design and communicating the model's results. The module enables students to prepare, analyse and summarise data, develop simple financial and actuarial spreadsheet models to solve financial and actuarial problems, and apply, interpret and communicate the results of such models.

Co-requisite: MA533 Contingencies II

MA549 Discrete Mathematics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	100% Exam	
1	Canterbury	Autumn	H	15 (7.5)	90% Exam, 10% Coursework	
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	Woodcock Dr C

Contact Hours

38

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the level 6 module students will be able to:
1 demonstrate systematic understanding of key aspects of the theory and practice of finite fields and their application to Latin squares, cryptography, m-sequences and cyclic codes;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a reasonable level of skill in calculation and manipulation of the material in the following areas: modular arithmetic, factorising polynomials, construction of finite fields, Latin squares, classical and public key ciphers including RSA, m-sequences and cyclic codes;
3 apply key aspects of discrete mathematics in well-defined contexts, showing judgement in the selection and application of tools and techniques.

The intended generic learning outcomes.
On successfully completing the level 6 module students will be able to:
1 manage their own learning and make use of appropriate resources;
2 understand logical arguments, identifying the assumptions made and the conclusions drawn;
3 communicate straightforward arguments and conclusions reasonably accurately and clearly;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make competent use of information technology skills such online resources (Moodle), internet communication;
7 communicate technical material competently;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

N L Biggs, Discrete Mathematics, Oxford University Press, 2nd edition, 2002
D Welsh, Codes and Cryptography, Oxford University Press, 1988
R Hill, A First Course in Coding Theory, Oxford University Press, 1980

Pre-requisites

For delivery to students completing Stage 1 before September 2016:
Pre-requisite: MA322 (Proofs and Numbers), MA323 (Matrices and Probability) or MA326 (Matrices and Computing), and MA553 (Linear Algebra)
Recommended: MA565 (Groups and Rings)
Co-requisite: None

For delivery to students completing Stage 1 after September 2016:
Pre-requisite: MAST4001 (Algebraic Methods) or MAST4005 (Linear Mathematics)
Co-requisite: None

Synopsis *

Discrete mathematics has found new applications in the encoding of information. Online banking requires the encoding of information to protect it from eavesdroppers. Digital television signals are subject to distortion by noise, so information must be encoded in a way that allows for the correction of this noise contamination. Different methods are used to encode information in these scenarios, but they are each based on results in abstract algebra. This module will provide a self-contained introduction to this general area of mathematics.
Syllabus: Modular arithmetic, polynomials and finite fields. Applications to
• orthogonal Latin squares,
• cryptography, including introduction to classical ciphers and public key ciphers such as RSA,
• "coin-tossing over a telephone",
• linear feedback shift registers and m-sequences,
• cyclic codes including Hamming,

MA552 Analysis

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	I	15 (7.5)	100% Exam	
1	Canterbury	Autumn	I	15 (7.5)	80% Exam, 20% Coursework	
1	Canterbury	Autumn	I	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

48 hours, Teaching methods involve a mix of lecture and example class activity.

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will:
a. have acquired a competence with the basic techniques of Analysis so that when these are needed as tools for the development and exploration of topics encountered in subsequent parts of their programme these same students can engage with confidence and some facility
b. have revisited and, as a remedial activity, practised the fundamental manipulative skills of elementary algebra and Calculus
c. understand the limitations, both in rigour and in scope, of the methods of Calculus they have previously met
d. begin to appreciate the effectiveness of topological ideas when it is necessary to work beyond the range of algorithmic methods
e. have attained a competence with limiting arguments and processes, in the contexts of convergence of real sequences and series, continuity and differentiability of real functions, and integrals
f. know the power of the Intermediate Value Theorem and the Mean Value Theorem as tools both for establishing results about functions in general, and also for analysing individual functions they are likely thereafter to encounter
g. have attained a competence with Taylor expansions, in the variety of examples and their ranges of validity, and with power series more generally.

The intended generic learning outcomes. On successful completion of the module, students will :
a. have matured in their problem formulating and solving skills, by a shift from the uncritical formal approach often adequate at earlier levels, towards a preoccupation with the sense and meaning conveyed by the symbols of their mathematical language
b. have enhanced their capacity to communicate mathematical statements and conclusions, both symbolically and literally

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

FM Hart Guide to ANALYSIS. (Palgrave Macmillan, 2001).
D.A. Brannan A First Course in Mathematical Analysis. (C.U.P. 2006)

Pre-requisites

MA321, MA322 and MA323 or MA326. This module is compulsory in all Mathematics based degree programmes.

Synopsis *

This module will consider many concepts you know from Calculus and put them on a more rigorous basis. The concept of a limit is basic to Calculus and, unless this concept is defined precisely, uncertainties and paradoxes will creep into the subject. Based on the foundation of the real number system, this module develops the theory of convergence of sequences and series and the study of continuity and differentiability of functions. The notion of Riemann integration is also explored. The syllabus includes the following: Sequences and their convergence. The convergence of bounded increasing sequences. Series and their convergence: the comparison test, the ratio test, absolute and conditional convergence, the alternating series test. Continuous functions: the boundedness theorem, the Intermediate Value Theorem. Differentiable functions: The Mean Value Theorem with applications, power series, Taylor expansions. Construction and properties of the Riemann integral.

MA553 Linear Algebra

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	I	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

Up to 48 hours of lectures and example classes

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of the module students:
(a) should have a reasonable understanding of the definitions and terms relating to Linear Algebra introduced in the module;
(b) should have a reasonable understanding of the statements, proofs and implications of the basic theorems given in the module (sufficiently well to be able to construct simple proofs of related results);
(c) should have confidence and reasonable skill in calculating with matrices and in specific vector spaces, etc. using the theorems derived during the module and with relatively little
guidence;
(d) should have developed a critical appreciation of the central role of linear algebra in Mathematics
and in its applications;
(e) should be able to present simple arguments and conclusions in Linear Algebra with reasonable
clarity;
(f) should be aware of the possibilities for using Maple to solve simple problems just beyond the range of "hand calculation".

The Intended Generic Learning Outcomes. On successful completion of the Module students will have:
-developed their problem-solving skills in relation to Linear Algebra.
-have acquired a reasonable facility in numerical and symbolic calculation with matrices and other related constructs in Linear Algebra.
-have furthered their time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effective modes of working.
-have furthered their study skills in an area that lies at the heart of most advanced Mathematics,
Statistics and applications of these areas and is therefore valuable for continuing professional development.

Method of Assessment

90% Examination, 10% Coursework

Preliminary Reading

S Lipschutz Linear Algebra. (Schaum's Outline Series, McGraw-Hill, N.Y., 1974) (R)
L Smith Linear Algebra. (Springer-Verlag, N.Y., 1984) (B)
G Strang Linear Algebra. (3rd ed., Harcourt, Brace, Jovanovich, San Diego, 1988) (B)

Pre-requisites

MA321, MA322 and MA323 or MA326

Synopsis *

Systems of linear equations appear in numerous applications of mathematics. Studying solution sets to such systems leads to the abstract notions of a vector space and a linear transformation. Matrices can be used to represent linear transformations and to do concrete calculations. This module is about the properties of vector spaces, linear transformations and matrices. The syllabus includes: vector spaces, linearly independent and spanning sets, bases, dimension, subspaces, linear transformations, the matrix of a linear transformation, similar matrices, the determinant, diagonalisation, bilinear forms, norms, and the Gram-Schmidt process.

MA561 Introduction to Lie Groups and Algebras

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
3	Canterbury	Autumn	M	15 (7.5)	70% Exam, 30% Coursework	

Contact Hours

30 hours

Learning Outcomes

On successful completion of this module, H-level students will
(i) be aware of the range of algebraic, geometric and analytic issues that the study of Lie groups and Lie algebras entail, be able to reason confidently from algebraic definitions such as ideals, bilinear forms, representations and root spaces, be able to calculate confidently with basic constructions such as vector fields, Lie brackets, exponentials, and adjoint representations, and be able to determine the Lie algebra of a Lie group and in particular to understand its nature as a tangent space to the group;
(ii) have developed intuition for the structure of the main examples of Lie groups and Lie algebras that arise in applications, including nonlinear Lie group actions;
(iii) developed awareness of non-commutative phenomena;
(iv) be aware of topics which are an important tool of research in many areas of Mathematics, Physics and Chemistry.
(v) have understood and be able to discuss the role played by Lie groups and algebras in at least one application area in detail;
(vi) have used the computer algebra package MAPLE to perform calculations in specified Lie groups and Lie algebras.

On successful completion of this module, M-level students will also:
(vii) have a systematic understanding of the algebraic, geometric and analytic issues that the study of Lie algebras and Lie groups entail;
(viii) have developed a comprehensive understanding of techniques for the application of Lie algebra.

Method of Assessment

70% Examination, 30% Coursework

Preliminary Reading

ML Curtis, Matrix Groups. (Springer Verlag, Second edition, 1984) (B)
R Gilmore, Lie groups, Lie algebras, and some of their applications. (New York, Wiley, 1974) (R)
N Jacobson, Lie algebras. (New York, Interscience Publishers, 1962) (B)
AW Knapp, Lie groups beyond an introduction. (Birkhäuser, Second edition, 2002) (B)
K Tapp, Matrix groups for undergraduates. (Student Mathematical Library 29, American Mathematical Society, 2005) (R)

A Fässler & E Stiefel, Group Theoretical Methods and their applications. (Boston, Birkhäuser, 1992) (R)

Synopsis *

Lie groups and their associated Lie algebras are studied by both pure and applied mathematicians and by physicists; this is a topic renowned for both its mathematical beauty and its immense utility. Lie groups include translation, rotation and scaling groups as well as unitary, symplectic and special linear matrix groups. We will study in detail the lower dimensional groups that arise in many applications, and more general theory such as the structure of their associated Lie algebras. Special topics include a look at the lowest dimensional exceptional Lie group G2, and Lie group actions and their invariants.

MA565 Groups and Rings

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	I	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

48

Learning Outcomes

On successful completion of this module students will be able to:
a) cite and understand a representative selection of the definitions and terms of basic Group Theory and Ring Theory;
b) cite examples of the main mathematical structures introduced including groups, subgroups, quotient groups, rings, subrings, ideals and homomorphisms;
c) execute simple proofs and deductions from the axioms for these structures and express the reasoning with reasonable clarity;
d) perform simple calculations for specific examples of these structures;
e) appreciate the relevance of abstract algebraic structures to related areas of mathematics

Method of Assessment

80% Examination, 20% Coursework

Pre-requisites

MA325 (From Geometry to Algebra)

Synopsis *

Groups are sets with a single binary operation. They arise as symmetry groups in contexts from puzzles like Rubik's cube to chemistry, where they help list molecules with a given number of atoms involved. In contrast, rings have two binary operations, generalising the arithmetic of integer numbers. This part of algebra has many applications in electronic communication, in particular in coding theory and cryptography. Outline Syllabus includes: permutations and cycle decomposition, subgroups, cosets, Lagrange's theorem, normal subgroups, symmetry groups, group actions, homomorphisms of groups and rings, ideals, factorization in rings, polynomial rings, domains, fields, quotient fields, finite fields.

MA567 Topology

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	Sibilla Dr N

Contact Hours

38

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of this module, students will be able to:
1 understand the basic concepts of topology;
2 apply notions from point-set topology to problems in geometry;
3 appreciate non-Euclidean geometric concepts;
4 develop awareness of relations to other mathematical areas such as Calculus, Metric Spaces and Functional Analysis.

The intended generic learning outcomes. On successful completion of the module, the students will have:
1 an enhanced ability to reason and deduce confidently from given definitions and constructions;
2 enhanced knowledge of associated abstract geometric concepts with applications;
3 matured in their problem formulating and solving skills;
4 consolidated their grasp of a wide variety of mathematical skills and methods.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

J.G. Hocking and G. Young: Topology, Dover Publications, 1988
J.R. Munkres: Topology, a first course, Prentice-Hall, 1975
C. Adams and A. Franzosa: Introduction to Topology, pure and applied, Pearson Prentice-Hall, 2008

Pre-requisites

For delivery to students completing Stage 1 before September 2016:
Pre-requisite: MA552 (Analysis)
Co-requisite: None

For delivery to students completing Stage 1 after September 2016:
Pre-requisite: MAST5013 (Real Analysis 2)
Co-requisite: None

Synopsis *

This module is an introduction to point-set topology, a topic that is relevant to many other areas of mathematics. In it, we will be looking at the concept of topological spaces and related constructions. In an Euclidean space, an "open set" is defined as a (possibly infinite) union of open "epsilon-balls". A topological space generalises the notion of "open set" axiomatically, leading to some interesting and sometimes surprising geometric consequences. For example, we will encounter spaces where every sequence of points converges to every point in the space, see why for topologists a doughnut is the same as a coffee cup, and have a look at famous objects such as the Moebius strip or the Klein bottle.

MA568 Orthogonal Polynomials and Special Functions

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	Soares Loureiro Dr A

Contact Hours

38

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of this module, students will be able to:
a) understand the basic concepts of orthogonal polynomials and special functions;
b) have sound knowledge of inner products in L2-spaces as well as the skills to apply this knowledge to problems in differential and difference equations;
c) understand how to apply the theory of analytical functions, differential and difference equations and asymptotic methods.

The intended generic learning outcomes
On successful completion of the module, the students will have:
a) an enhanced ability to reason and deduce confidently from given definitions and constructions;
b) enhanced knowledge of special functions and their geometric, analytical and asymptotic properties;
c) matured in their problem formulating and solving skills;
d) consolidated their grasp of a wide variety of mathematical skills and methods.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The module does not follow a specific text. However, the following texts cover the material.
R. Askey, Orthogonal Polynomials and Special Functions, Society for Industrial and Applied Mathematics, Philadelphia, PA, 1975
R. Beals and R. Wong, Special Functions – A Graduate Text, Cambridge University Press, Cambridge, 2010
T.S. Chihara, An Introduction to Orthogonal Polynomials, Dover Publ., Mineola, N.Y., 2011
M. Ismail, Classical and Quantum Orthogonal Polynomials in One Variable, Cambridge University Press, Cambridge, 2005
F.W.J. Olver, D.W. Lozier, C.W. Clark,R.F. Boisvert, Digital Library of Mathematical Functions, National Institute of Standards and Technology, Gaithersburg, U.S.A., 2010 (http://dlmf.nist.gov)
I.N. Sneddon, Special Functions of Mathematical Physics and Chemistry, 3rd Edition, Longman, London, 1980
G. Szego, Orthogonal Polynomials, 4th Ed., American Mathematical Society, Providence, RI, 1975

Pre-requisites

For delivery to students completing Stage 1 before September 2016:
Pre-requisite: MA321 (Calculus and Mathematical Modelling), MA322 (Proofs and Numbers), MA323 (Matrices and Probability), MA552 (Analysis), MA588 (Mathematical Techniques and Differential Equations).

For delivery to students completing Stage 1 after September 2016:
Pre-requisite: MAST4004 (Linear Algebra); MAST4010 (Real Analysis 1); MAST5013 (Real Analysis 2); MAST5012 (Ordinary differential equations).

Synopsis *

This module provides an introduction to the study of orthogonal polynomials and special functions. They are essentially useful mathematical functions with remarkable properties and applications in mathematical physics and other branches of mathematics. Closely related to many branches of analysis, orthogonal polynomials and special functions are related to important problems in approximation theory of functions, the theory of differential, difference and integral equations, whilst having important applications to recent problems in quantum mechanics, mathematical statistics, combinatorics and number theory. The emphasis will be on developing an understanding of the structural, analytical and geometrical properties of orthogonal polynomials and special functions. The module will utilise physical, combinatorial and number theory problems to illustrate the theory and give an insight into a plank of applications, whilst including some recent developments in this field. The development will bring aspects of mathematics as well as computation through the use of MAPLE. The topics covered will include: The hypergeometric functions, the parabolic cylinder functions, the confluent hypergeometric functions (Kummer and Whittaker) explored from their series expansions, analytical and geometrical properties, functional and differential equations; sequences of orthogonal polynomials and their weight functions; study of the classical polynomials and their applications as well as other hypergeometric type polynomials.

MA572 Complex Analysis

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	100% Exam	
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	
1	Canterbury	Autumn	H	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

48 (approx.. 36 lectures and 12 example classes).

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of this module students will:
a) Have a reasonable ability to perform basic computational skills: calculations with Cartesian and polar form of complex numbers, modulus and argument; roots of unity; partial fractions and the general binomial theorem; calculations with exponential, trigonometric and hyperbolic functions, complex logarithm and complex exponents, and hyperbolic functions.
b) Have a reasonable knowledge, and understand the place in the theory and the proofs: of the Cauchy Fundamental Theorem, Cauchy Integral Formulae with and without winding numbers, the Deformation Theorem, Existence and formulae for Taylor and Laurent series, differentiability of power series, Cauchy Residue Theorem, the Cauchy-Riemann equations, a proof of the Fundamental Theorem of Algebra..
c) Gain experience and solve problems using more advanced analytic skills such as: computation of Taylor and Laurent series; radius of convergence of power series; calculation of residues and types of singularity; evaluation of integrals using residues, possibly including the use of Riemann surfaces; homotopy of paths to ease calculations of path integrals; use of winding numbers of paths; evaluation of limits and differentiability of a complex function; conjugate harmonic functions.

The intended generic learning outcomes
Students who successfully complete this module will have further developed:
a) a logical mathematical approach to solving problems;
b) an ability to solve problems relevant to applications in engineering and physics;
c) the basic skills for postgraduate studies in topology, engineering mathematics and applied analysis.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

M.R. Spiegel Complex Variables, McGraw-Hill, 1964
H.A. Priestley Introduction to Complex Analysis, Oxford University Press, 2003
J.H. Mathews & R.W Howell Complex Analysis for Mathematics and Engineering, Jones and Bartlett 5th ed., 2006
I Stewart & D Tall, Complex Analysis, Cambridge, 2004

Pre-requisites

MA552 (for undergraduate courses only)

Synopsis *

This module is concerned with complex functions, that is functions which are both defined for and assume complex values. Their theory follows a quite different development from that of real functions, is remarkable in its directness and elegance, and leads to many useful applications.Topics covered will include: Complex numbers. Domains and simple connectivity. Cauchy-Riemann equations. Integration and Cauchy's theorem. Singularities and residues. Applications.

MA574 Polynomials in Several Variables

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	70% Exam, 30% Coursework	Shank Dr RJ
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	Shank Dr RJ
1	Canterbury	Spring	H	15 (7.5)	70% Exam, 30% Coursework	

Contact Hours

36

Learning Outcomes

On successfully completing the level 6 module students will be able to:
1 demonstrate systematic understanding of key aspects of polynomials in several variables;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a reasonable level of skill in calculation and manipulation of the material in the following areas: solution sets for systems of polynomial equations and the corresponding ideals in the ring of polynomials;
3 apply key aspects of polynomial in several variables in well-defined contexts, showing judgement in the selection and application of tools and techniques;
4 show judgement in the selection and application of computer calculation of Gröbner bases.

The intended generic learning outcomes.
On successfully completing the level 6 module students will be able to:
1 manage their own learning and make use of appropriate resources;
2 understand logical arguments, identifying the assumptions made and the conclusions drawn;
3 communicate straightforward arguments and conclusions reasonably accurately and clearly;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make competent use of information technology skills such online resources (Moodle), internet communication;
7 communicate technical material competently;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Adams, Loustaunau, An introduction to Gröbner bases, AMS, 1994
Cox, Little, O'Shea, Ideals, Varieties and Algorithms, Springer, Undergraduate Texts in Mathematics, 1991
Hibi, Gröbner bases: Statistics and Software Systems, Springer, 2013

Pre-requisites

For delivery to students completing Stage 1 before September 2016:
Pre-requisite: MA322 (Proofs and Numbers), MA323 (Matrices and Probability) or MA326 (Matrices and Computing), and MA553 (Linear Algebra)
Recommended: MA324 (Exploring Mathematics), MA565 (Groups and Rings)
Co-requisite: None

For delivery to students completing Stage 1 after September 2016:
Pre-requisite: MA343 (Algebraic Methods), MA5503 (Groups and Symmetries)
Recommended: MA5514 (Rings and Fields)
Co-requisite: None

Synopsis *

This module provides a rigorous foundation for the solution of systems of polynomial equations in many variables. In the 1890s, David Hilbert proved four ground-breaking theorems that prepared the way for Emmy Nöther's famous foundational work in the 1920s on ring theory and ideals in abstract algebra. This module will echo that historical progress, developing Hilbert's theorems and the essential canon of ring theory in the context of polynomial rings. It will take a modern perspective on the subject, using the Gröbner bases developed in the 1960s together with ideas of computer algebra pioneered in the 1980s. The syllabus will include
• Multivariate polynomials, monomial orders, division algorithm, Gröbner bases;
• Hilbert's Nullstellensatz and its meaning and consequences for solving polynomials in several variables;
• Elimination theory and applications;
• Linear equations over systems of polynomials, syzygies.

MA577 Elements of Abstract Analysis

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

48

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of the module students will:
(a) be able to work with fundamental concepts in analysis and metric spaces including, Cauchy sequences, compactness, completeness, inner-product spaces, and complete orthonormal systems;
(b) have a grasp of formal definitions and rigorous proofs in analysis;
(c) have gained an appreciation of a wider context in which previously encountered concepts from analysis can be used;
(d) be able to apply abstract ideas to concrete problems in analysis;
(e) be aware of applications of basic techniques and theorems of metric spaces and analysis in other areas of mathematics, e.g., approximation theory, and the theory of ordinary differential equations.

The Intended Generic Learning Outcomes. We expect students successfully completing the module to have
(i) an enhanced ability to correctly formulate abstract problems and solve them efficiently;
(ii) enhanced skills in understanding and communicating mathematical results and conclusions;
(iii) furthered a holistic view of mathematics as a problem solving and intellectually stimulating discipline;
(iv) an appreciation of the power of abstract reasoning and formal proofs in mathematics and its applications

On completion of the module students will have:
• matured in their problem formulating and solving skills;
• enhanced their ability to apply abstract methods and theorems from analysis in a wide context.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

- E Kreyszig, Introductory Functional Analysis with Applications. (John Wiley, 1978) (B)
- W Rudin, Principles of Mathematical Analysis. (International Series in Pure and Applied Mathematics, McGraw-Hill, 1976) (B)
- N Young, An Introduction to Hilbert space. (Cambridge University Press, 1998) (R)
- JR Giles, Introduction to the Analysis of Metric Spaces. (Australian Mathematical Society Lecture Series, Cambridge, 1987) (R)
- K Saxe, Beginning Functional Analysis. (Springer, 2002) (B)

Synopsis *

In this module we build on the key analytical concepts of sequences, series, limits,and continuity developed in any first course on Real Analysis, and place them in the more general context of metric spaces. In the first part of the course fundamental notions of metric spaces, such as compactness and completeness, are discussed. Metric space theory underpins much of modern anaylisis and its applications. In the second part of the course we use techniques and theorems from metric spaces to discuss elements of Hilbert space theory. The course emphasizes formal definitions and proofs, and aims to enable you to place your previous knowledge of anaylsis in a much wider context.

The syllabus will be taken from the following topics:
(1) Metric space theory.
• Definitions and examples of metric spaces, normed spaces, inner-product spaces.
• Balls, boundedness, open and closed sets.
• Convergence, Cauchy sequences, completeness, and equivalence of metrics.
• Completion of a metric space, uniform convergence, and exchanging limits.
• Incompleteness of the space of Riemann-integrable functions under Lp-norms, and an informal discussion of its completion, i.e., Lp-spaces. The space of continuous functions and supremum norm.
• Limit points, closure, boundary, separability, density.
• Banach contraction mapping theorem; applications to ODE theory (Picard's theorem), and/or integral equations.
• Continuity in metric spaces, uniform continuity, and continuity of linear mappings.
• Compactness, sequential compactness, Heine-Borel, Non-compactness of balls in infinite dimensional normed spaces.
• The spaces of continuous functions C(X) on a compact metric space X, and the Weierstrass approximation theorem.

(2) Basic Hilbert space theory.
• Definitions and examples of inner-product spaces, Hilbert spaces, Cauchy-Schwarz inequality, parallelogram identity, l2 and L2([a,b]).
• Orthogonal complements and orthogonal projections.
• Orthonormal sets and Gram-Schmidt orthogonalisation.
• Examples of orthogonal polynomials, e.g., Legendre polynomials and/or Chebyshev polynomials.
• Complete orthonormal systems, Bessel's inequality, Parseval's theorem, and the Riesz-Fisher theorem. Trigonometric series and L2 convergence.

MA584 Computational Mathematics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	I	15 (7.5)	85% Exam, 15% Coursework	

Contact Hours

48

Learning Outcomes

The intended subject specific learning outcomes.
A first Numerical Analysis encounter provides an introduction to the methods, tools and ideas of numerical computation. More specifically this module creates a bridge for the student between the theoretical activity involved in solving a mathematical problem and the practical task of calculating a numerical answer.
On successful completion of the module students will:
a. have attained a competence with the use of elementary numerical algorithms for undertaking specific tasks of a mathematical character, such as the calculation of the value of a definite integral, when analytical methods can make no headway
b. understand both how numbers are represented in a computer and also the nature of computer arithmetic, and in particular appreciate the difference between human calculation by hand and machine computation
c. understand the inevitability of numerical errors occurring during the course of machine computations, how these errors arise and propagate, and how they may be detected and controlled
d. have encountered basic facilities within matlab, for example how to undertake large-scale matrix calculations, and recognise that such systems encompass diagnostic aids that enable the monitoring of factors such as error growth
The intended generic learning outcomes. On successful completion of the module, students will:
a. have attained a competence in numerical computation of a sophisticated and relatively advanced character
b. have enhanced their ability to communicate mathematical and numerical statements and conclusions, both symbolically and literally
c. have developed advanced study skills by working on challenging problems that require the application of theoretical techniques in specific and practical contexts.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

RL Burden & JD Faires, Numerical Analysis, Thomson Brooks/Cole, 8th ed., 2005
Samuel D Conte & Carl de Boor, Elementary Numerical Analysis: An Algorithmic Approach, McGraw Hill, New York, 3rd ed., 1980
Robert Plato, Concise Numerical Mathematics, Americal Mathematical Society, Providance (RI), 2003
W Cheney & D Kincaid Numerical Mathematics and Computing (Thomson Brooks/Cle, 2004) (R)
LN Childs A Concrete Introduction to Higher Algebra (2nd ed., Springer, 2000) (R)
DR Knuth The Art of Computer Programming, Vol. 2 (3rd ed., Addison-Wesley, 2003) (B)

Pre-requisites

MA321, MA322 and MA323 or MA326

Synopsis *

The aim of the module is to provide an introduction to the methods, tools and ideas of numerical computation. In applications mathematics frequently generates specific instances of standard problems for which there are no easily obtainable analytic solutions. Examples might be the task of determining the value of a particular integral, or of finding the roots of a certain non- linear equation. Methods are presented for solving such problems on a modern computer. Besides a description of the basic numerical procedure, each method is analysed in terms of when it best works, how it compares with alternative approaches, and the way it may be implemented on a computer. Numerical computations are almost invariably contaminated by errors, and an important concern throughout the module is to understand the source, propagation and magnitude of these errors.The syllabus will cover: Introduction to numerics; solutions of equations in one variable; interpolation and polynomial approximation; numerical differentiation; numerical integration; direct methods for solving linear systems; iterative techniques for solving linear systems.

MA587 Numerical Solution of Differential Equations

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	Deano Cabrera Dr A
1	Canterbury	Autumn	H	15 (7.5)	90% Exam, 10% Coursework	Deano Cabrera Dr A
1	Canterbury	Spring	H	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

42

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:
1 demonstrate systematic understanding of key aspects of finite difference methods for approximating solutions of ordinary differential equations (ODEs) and partial differential equations (PDEs);
2 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a reasonable level of skill in calculation and manipulation of the material in the following areas: multistep methods, approximation of boundary value problems for ODEs, discretization of PDEs, error and stability analysis, elementary numerical linear algebra;
3 apply key aspects of finite difference methods in well-defined contexts, showing judgement in the selection and application of tools and techniques;
4 show judgement in the selection and application of Matlab commands to implement numerical methods.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1 manage their own learning and make use of appropriate resources;
2 understand logical arguments, identifying the assumptions made and the conclusions drawn;
3 communicate straightforward arguments and conclusions reasonably accurately and clearly;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make competent use of information technology skills such as online resources (Moodle), internet communication;
7 communicate technical material competently;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Burden, R.L., and Faires, J.D., and Burden, A. M., Numerical Analysis, 10th edition, Cengage Learning, 2016
Iserles, A first course in the numerical analysis of differential equations, 2nd edition, Cambridge University Press, 2009
Morton, K. W. and Mayers, D.F., Numerical solution of partial differential equations: an introduction, Cambridge University Press, 2011

Pre-requisites

For delivery to students completing Stage 1 before September 2016:
Pre-requisite: MA552 (Analysis), MA553 (Linear Algebra)
Co-requisite: None

For delivery to students completing Stage 1 after September 2016:
Pre-requisite: MAST5005 (Linear Partial Differential Equations), MAST5009 (Numerical Methods), MAST5012 (Ordinary differential equations)
Co-requisite: None

Synopsis *

Most differential equations which arise from physical systems cannot be solved explicitly in closed form, and thus numerical solutions are an invaluable way to obtain information about the underlying physical system. The first half of the module is concerned with ordinary differential equations. Several different numerical methods are introduced and error growth is studied. Both initial value and boundary value problems are investigated. The second half of the module deals with the numerical solution of partial differential equations. The syllabus includes: initial value problems for ordinary differential equations; Taylor methods; Runge-Kutta methods; multistep methods; error bounds and stability; boundary value problems for ordinary differential equations; finite difference schemes; difference schemes for partial differential equations; iterative methods; stability analysis.

MA588 Mathematical Techniques and Differential Equations

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	I	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

36 hours of lectures, 12 classes

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of the module students will:
a. be able to solve linear ordinary differential equations by series;
b. understand the concept of the Fourier series expansion of a function;
c. be able to solve partial differential equations by separation of variables;
d. understand how Fourier series and special functions arise in the solution of boundary and initial value problems in applied mathematics and mathematical physics;
e. appreciate the uses of Fourier transforms and be able to calculate them for simple functions
f. appreciate the mathematical and physical aspects of the solutions of the equations considered, as well as their computation with MAPLE.

The Intended Generic Learning Outcomes. On successful completion of the Module, students will have developed:
- an analytical approach to solving problems in applied mathematics and physics involving ordinary and partial differential equations;
- their ability to communicate these solutions and calculations;
- their numeracy and computational skills;
- their ability to plan and carry out effective ways of studying;
- their key skills in numeracy, problem solving and computing.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

E Kreyszig Advanced Engineering Mathematics. (Wiley)
CR Wylie and LC Barrett Advanced Engineering Mathematics. (6th ed., McGraw Hill, 1985)
RK Nagle and EB Saff Fundamentals of Differential Equations. (6th ed., Addison Wesley, 2004)
R Haberman Elementary applied partial differential equations: with Fourier series and boundary value problems (Prentice-Hall, 1987)

Pre-requisites

MA321 Calculus and Mathematical Modelling, MA322 Proofs and Numbers, and MA323 Matrices and Probability or MA326 Matrices and Computing or equivalent modules

Synopsis *

We will study ordinary differential equations analytically, going beyond the exact techniques studied in MA321. We will also learn how to solve partial differential equations and apply the techniques to phenomena such as the vibration of a guitar string or a drum skin. Outline syllabus includes: Series Solutions of Linear Ordinary Differential Equations, Orthogonal polynomials and Special functions, Fourier Series and Transforms and Partial Differential Equations.

MA590 Mathematical Modelling

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	I	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

36 lectures, 12 classes

Learning Outcomes

On successful completion of this module students will:
a) have a reasonable knowledge of the various concepts and quantities required in population models and Newtonian mechanics;
b) be aware of how these quantities are linked by equations, using vectors and matrices where appropriate;
c) have a reasonable ability to derive and study these equations and interpret the results in terms of the original concepts;
d) have a reasonable ability to use MAPLE to illustrate the behaviour of population models;
e) appreciate the applications of Linear Algebra in mathematical modelling.

Students who successfully complete this module will have further developed:
a) an analytical approach to solving problems;
b) their ability to communicate solutions, simple proofs and calculations;
c) their numeracy and computational skills;
d) their ability to plan and carry out effective ways of studying.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

J Berry and K Houston, “Mathematical Modelling: mechanical vibrations, population dynamics, and traffic flow : an introduction to applied mathematics”, Edward Arnold, London, 1995.
D Edwards and M Hamson, “Guide to Mathematical Modelling”, Palgrave, Basingstoke, 1989.
M Lunn, “A First Course in Mechanics”, Oxford University Press, New York, Oxford, 1991.
R K Nagle and E B Saff, “Fundamentals of Differential Equations”, Addison Wesley, 6th Ed., Boston, Mass., London, 2004.
P J Olver and C Shakiban, “Applied Linear Algebra”, Prentice-Hall, Upper Saddle River, NJ, 2006.
P Dyke, R Whitworth, “Guide to mechanics”, Macmillan, Basingstoke, 1992. • P Smith and R Charles, “Mechanics”, Wiley, 2nd Ed., Chichester, 1990.

Pre-requisites

MA321, MA322 and MA323 or MA326

Synopsis *

This module introduces mathematical modelling in a variety of contexts including using Newton's laws of motion, Newton’s law of gravitation, population models, exponential growth, density dependent growth, and predator-prey models. Outline syllabus may include topics from (i) deriving differential equations from data; dimensional analysis; (ii) discrete models and difference equations: steady states and their stability; (iii) continuous models and ordinary differential equations: steady states and their stability; the slope fields and phase lines; (iv) applications of Linear Algebra (in lower dimensions): systems of linear ordinary differential equations; linear phase plane analysis and stability; (v) electrical networks; (vi) vector algebra, vector geometry, vector equations, coordinate systems and vector differentiation; (vii) application in mechanics: Newton's laws for a single particle in 3-D; conserved quantities; angular velocity, angular momentum, moment of a force; harmonic motion.

MA591 Nonlinear Systems and Mathematical Biology

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

36 lectures, 12 classes

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of this module students will:
a) appreciate a variety of different nonlinear phenomena;
b) be able to derive qualitative results for nonlinear ordinary/ partial differential and difference equations;
c) know how to analyse and interpret basic mathematical models of biological systems;
d) have an understanding of the concepts of bifurcation, chaos, and equilibrium stability in nonlinear dynamical systems;
e) be able to synthesize analytical, geometrical and numerical techniques, as well as computation with MAPLE, in the description of real world phenomena from biology.

The intended generic learning outcomes
Students who successfully complete this module will have developed:
a) a qualitative approach to the analysis of problems in mathematical biology through the use of nonlinear dynamical systems;
b) their ability to communicate the results of calculations and the solutions of problems;
c) their numeracy and computational skills;
d) their ability to plan and carry out effective ways of studying;
e) their key skills in numeracy, problem solving and computing.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

JD Murray - Mathematical Biology. (2nd ed. Springer-Verlag 1993) (E)
and Mathematical Biology, Volumes I & II (3rd ed., Springer-Verlag 2002-3) (R)
DW Jordan and P Smith Nonlinear Ordinary Differential Equations (3rd Ed, Oxford 1999). ®
D Kaplan and L Glass Understanding Nonlinear Dynamics. (Springer 1995)
P Glendinning Stability, instability and chaos (Cambridge, 1994)

Pre-requisites

MA552 and MA553; MA590 are recommended

Synopsis *

This module provides an introduction to the study of properties of solutions of nonlinear ordinary differential equations, difference equations and their application to problems in Biology. The emphasis will be on developing an understanding of nonlinear systems and using practical analytical techniques to analyse them. The module will utilise biological models to illustrate the theory and give an insight into how Mathematics can be of practical use in the study of phenomena which are observed in the real world. The module will cover topics in the following areas: Continuous population models for single species; Discrete population models; Phase plane analysis; Continuous models for Interacting Populations (including predator-prey, competition and mutualism models); Stability, instability and limit cycles; Reaction kinetics; Reaction-diffusion models.

MA602 Project in Statistics or Probability

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	95% Project, 5% Coursework	Wood Dr I

Contact Hours

13

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:
1 demonstrate appreciation of an area of statistics or probability in more depth than in taught courses;
2 apply skills in mathematical computation relevant to the topic;
3 draw conclusions from statistical data, mathematical calculations and/or computer output;
4 apply mathematical concepts and statistical techniques in a particular context;
5 write a coherent account of an area of statistics or probability;
6 perform computations that show their understanding of the techniques relevant to the topic;
7 demonstrate an improved ability in mathematical and statistical modelling.

The intended generic learning outcomes.
On successfully completing the module students will have:
1 improved communication skills;
2 enhanced intellectual independence;
3 relevant computing skills, including use of appropriate document preparation and word- processing packages;
4 improved problem solving skills;
5 awareness of important issues relating to good written presentation of results;
6 improved ability to select material from source texts, either recommended to or found by the student, and shown awareness of the relationship of the material to background and to more advanced material;
7 improved ability for independent learning and time management.

Method of Assessment

95% Project, 5% Coursework

Preliminary Reading

Texts depend on the projects offered. For the Key Skills component:
A Primer of Mathematical Writing, Stephen G. Krantz, American Mathematical Society, 1997. The LaTeX Companion by Frank Mittelbach et al., Addison Wesley; 2 edition (23 April 2004).
How to think like a mathematician: a companion to undergraduate mathematics - Houston, Kevin, CUP 2009.
Handbook of writing for the mathematical sciences - Higham, Nicholas J., SIAM, 1998.

Pre-requisites

Co-requisites are MA629 and MA632

Synopsis *

This modules offer students the opportunity to work on a project in statistics or probability. Student choose a project and supervisor during the Autumn term and work on the project with the support of the supervisor in the Spring term. The module offers the opportunity to develop their skills in self-study and report writing.

MA612 Regression Models

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

41, 36 lectures and 5 hours of computing workshops

Learning Outcomes

On successful completion of this module, students will be able to demonstrate:
(a) a reasonable ability to derive, from first principles and using matrix algebra, theoretical results relating to fitting regression models by least squares;
(b) a reasonable ability to fit regression models to data, and carry out related statistical inferences, using both hand calculation and appropriate computer software;
(c) a reasonable ability to use residual plots and other techniques to check the assumptions underlying regression analysis;
(d) a reasonable ability to identify outlying and influential observations;
(e) a reasonable ability to choose between alternative models for sets of data.
(f) a systematic understanding of the areas of simple linear and multiple regression modelling.
(g) an ability to explore the statistical literature to extend their knowledge of regression modelling to include logistic regression models.

Method of Assessment

90% Examination, 10% Coursework

Preliminary Reading

Draper,N.R. and Smith, H. (1998) Applied Regression Analysis. 3rd edition, New York, Wiley. [Recommended]
Chatterjee, S and Hadi, A.S. (2012) Regression Analysis by Example. 5th edition, Hoboken, New Jersey, Wiley. [Background]
Freedman, D.A. (2005) Statistical Models: Theory and Practice, Cambridge University Press. [Background]
Collett, D. (2003) Modelling Binary Data. 2nd edition. Boca Raton, Chapman & Hall/CRC. [Recommended]
Dobson, A.J. and Barnett, A. G. (2008) An Introduction to Generalized Linear Models. 3rd edition. Boca Raton, Chapman & Hall/CRC. [Recommended]

Pre-requisites

MA306, MA321, MA322 and MA323 or MA312

Synopsis *

Regression is a fundamental technique of statistical modelling, in which we aim to model a response variable using one or more explanatory variables. For example, we might want to model the yield of a chemical process in terms the temperature and pressure of the process. The need for statistical modelling arises because even when temperature and pressure are fixed, there will typically be variation in the resulting yield, so the model must include a random component. In this module we study the broad class of linear regression models, which are widely used in practice. We learn how to formulate such models and fit them to data, how to make predictions with associated measures of uncertainty, and how to select appropriate explanatory variables. Both theory and practical aspects are covered, including the use of computer software for regression. Through directed reading, students will also explore logistic regression models that are applicable when the response variable can take just two possible values. Outline of the syllabus: simple linear regression; the method of least squares; sums of squares; the ANOVA table; residuals and diagnostics; matrix formulation of the general linear model; prediction; variable selection; one-way analysis of variance; practical regression analysis using software.

MA619 Probability and Inference

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

42-48 lectures and example classes/workshops

Learning Outcomes

On successful completion of this module, students will be able to demonstrate:
a) a reasonable knowledge of probability theory and of the key ideas of statistical inference, in particular to enable them to study further statistics modules at levels I and H (for which this module is a pre-requisite);
b) a reasonable ability to use mathematical techniques to manipulate joint, marginal and conditional probability distributions, and to derive distributions of transformed random variables;
c) a reasonable ability to use mathematical techniques to calculate point and interval estimates of parameters and to perform tests of hypotheses;
d) some appreciation of the relevance of mathematical statistics to real world problems.
e) a systematic understanding of the areas of probability theory and frequentist statistics covered by this module, in particular to enable them to study further statistics modules at levels H and M (for which this module is a pre-requisite);
f) an ability to explore the statistical literature to extend their experience in frequentist statistics into the area of Bayesian inference.

Method of Assessment

90% Examination, 10% Coursework

Preliminary Reading

MILLER, I. and MILLER, M. (2003) [Recommended]
John E. Freund's Mathematical Statistics with Applications. 7th international edition.
Pearson Education, Prentice Hall, New Jersey.
LINDLEY, D.V. and SCOTT, W.F. (1995) [Recommended]
New Cambridge Statistical Tables. 2nd edition.
HOGG, R., CRAIG, A. and McKEAN, J. (2003) [Background]
Introduction to Mathematical Statistics. 6th international edition.
LARSON, H. J. (1982) [Background]
Introduction to Probability Theory and Statistical Inference. 3rd edition.
SPIEGEL, M. R, SCHILLER, J. and ALU SRINIVASAN, R. (2000) [Background]
Schaum's Outline of Probability and Statistics. 2nd edition.
LEE, P. M. (2012) [Recommended for H-level students]
Bayesian Statistics an Introduction. 4th edition. (ebook)

Synopsis *

ONLY AVAILABLE TO INTERNATIONAL MASTERS STUDENTS: This module is a pre-requisite for many of the other statistics modules at Stages 1 and 2, but it can equally well be studied as a module in its own right. It starts by revising the idea of a probability distribution for one or more random variables and looks at different methods to derive the distribution of a function of random variables. These techniques are then used to prove some of the results underpinning hypothesis test and confidence interval calculations, such as for the t-test or the F-test. With these tools to hand, the module moves on to look at how to fit models (probability distributions) to sets of data. A standard technique, known as the method of maximum likelihood, is introduced, which is then used to fit the model to the data to obtain point estimates of the model parameters and to construct hypothesis tests and confidence intervals for these parameters. The module concludes with a directed reading task to explore some of the ideas of Bayesian inference. Outline Syllabus includes: Joint, marginal and conditional distributions of discrete and continuous random variables; Generating functions; Transformations of random variables; Sampling distributions; Point and interval estimation; Properties of estimators; Maximum likelihood; Hypothesis testing; Neyman-Pearson lemma; Maximum likelihood ratio test. Bayesian inference: prior and posterior distributions, conjugate prior, loss function, Bayesian estimators and credible intervals.

MA629 Probability and Inference

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	I	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

42-48 lectures and example classes/workshops

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of this module, level 5 students will be able to demonstrate:
a) a reasonable knowledge of probability theory and of the key ideas of statistical inference, in particular to enable them to study further statistics modules at levels I and H (for which this module is a pre-requisite);
b) a reasonable ability to use mathematical techniques to manipulate joint, marginal and conditional probability distributions, and to derive distributions of transformed random variables;
c) a reasonable ability to use mathematical techniques to calculate point and interval estimates of parameters and to perform tests of hypotheses;
d) some appreciation of the relevance of mathematical statistics to real world problems.

On successful completion of this module, level 6 students will also be able to demonstrate:
e) a systematic understanding of the areas of probability theory and frequentist statistics covered by this module, in particular to enable them to study further statistics modules at levels H and M (for which this module is a pre-requisite);
f) an ability to explore the statistical literature to extend their experience in frequentist statistics into the area of Bayesian inference.

12. The intended generic learning outcomes
On successful completion of this module, level 5 students will have:
a) developed their understanding of probability and statistics;
b) applied a range of mathematical techniques to solve statistical problems;
c) developed their ability to abstract the essentials of problems and to formulate them mathematically;
d) improved their key skills in numeracy and problem solving;
e) enhanced their study skills and ability to work with relatively little supervision.

On successful completion of this module, level 6 students will also have:
f) demonstrated an ability to extend their existing knowledge of statistics into new areas through independent study.

Method of Assessment

90% Examination, 10% Coursework

Preliminary Reading

I Miller & M Miller John E Freund's Mathematical Statistics with Applications, 7th ed., Pearson Education, Prentice Hall, New Jersey, 2003 (QA276).(R)
RV Hogg, JW McKean & AT Craig Introduction to Mathematical Statistics, 6th ed., Prentice Hall, 2003 (QA276) (B)
HJ Larson Introduction to Probability Theory and Statistical Inference. (3rd ed., Wiley, 1982) (HA29)(B)

Pre-requisites

Students need to have passed the first-year examinations for Mathematics or a related degree programme.

Synopsis *

This module is a pre-requisite for many of the other statistics modules at Stages 2, 3 and 4, but it can equally well be studied as a module in its own right, extending the ideas of probability and statistics met at Stage 1 and providing practice with the mathematical skills learned in MA321. It starts by revising the idea of a probability distribution for one or more random variables and looks at different methods to derive the distribution of a function of random variables. These techniques are then used to prove some of the results underpinning the hypothesis test and confidence interval calculations met at Stage 1, such as for the t-test or the F-test. With these tools to hand, the module moves on to look at how to fit models (probability distributions) to sets of data. A standard technique, known as the method of maximum likelihood, is introduced, which is then used to fit the model to the data to obtain point estimates of the model parameters and to construct hypothesis tests and confidence intervals for these parameters. Outline Syllabus includes: Joint, marginal and conditional distributions of discrete and continuous random variables; Generating functions; Transformations of random variables; Sampling distributions; Point and interval estimation; Properties of estimators; Maximum likelihood; Hypothesis testing; Neyman-Pearson lemma; Maximum likelihood ratio test.

MA632 Regression

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	I	15 (7.5)	90% Exam, 10% Coursework	
2	Canterbury	Spring	I	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

36 lectures and up to 12 hours practical sessions

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of this module, level 5 students will be able to demonstrate:
(a) a reasonable ability to derive, from first principles and using matrix algebra, theoretical results relating to fitting regression models by least squares;
(b) a reasonable ability to fit regression models to data, and carry out related statistical inferences, using both hand calculation and appropriate computer software;
(c) a reasonable ability to use residual plots and other techniques to check the assumptions underlying regression analysis;
(d) a reasonable ability to identify outlying and influential observations;
(e) a reasonable ability to choose between alternative models for sets of data.

On successful completion of this module, level 6 students will also be able to demonstrate:
(f) a systematic understanding of the areas of simple linear and multiple regression modelling.
(g) an ability to explore the statistical literature to extend their knowledge of regression modelling to include logistic regression models.

The intended generic learning outcomes
The module provides an introduction to the theory and practice of regression. Students should emerge with an appreciation of the power of this technique, and with the ability to use it in the analysis of data.
On successful completion of the Module, level 5 students will have:
(a) developed their understanding of probability and statistics;
(b) applied a range of mathematical techniques to solve statistical problems;
(c) developed their ability to abstract the essentials of problems and to formulate them independently;
(d) improved their key skills in written communication, numeracy and problem solving;
(e) developed their ability to use statistical software;
(f) enhanced their study skills and ability to work with relatively little supervision.

On successful completion of the Module, level 6 students will also have:
(g) demonstrated an ability to extend their existing knowledge of statistics into new areas through independent study.

Method of Assessment

90% Examination, 10% Coursework

Preliminary Reading

S Chatterjee, A Hadi Regression analysis by Example. (New York: Wiley, 3rd ed. 1999, 4th ed. 2006)
N R Draper, H Smith Applied Regression Analysis. (New York: Wiley. 1998) (R)
DA Freedman Statistical Models: Theory and Practice. (Cambridge, University Press, 2005)

Pre-requisites

MA321, MA322, MA323 or MA326, MA306 or MA319

Restrictions

Synopsis *

Regression is a fundamental technique of statistical modelling, in which we aim to model a response variable using one or more explanatory variables. For example, we might want to model the yield of a chemical process in terms of the temperature and pressure of the process. The need for statistical modelling arises because even when temperature and pressure are fixed, there will typically be variation in the resulting yield, so the model must include a random component. In this module we study the broad class of linear regression models, which are widely used in practice. We learn how to formulate such models and fit them to data, how to make predictions with associated measures of uncertainty, and how to select appropriate explanatory variables. Both theory and practical aspects are covered, including the use of computer software for regression. Outline of the syllabus: simple linear regression; the method of least squares; sums of squares; the ANOVA table; residuals and diagnostics; matrix formulation of the general linear model; prediction; variable selection; one-way analysis of variance; practical regression analysis using software; logistic regression.

MA636 Stochastic Processes

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	Zhang Prof J (MA)
1	Canterbury	Autumn	H	15 (7.5)	90% Exam, 10% Coursework	Zhang Prof J (MA)

Contact Hours

48 hours

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the level 6 module students will be able to:
1 demonstrate systematic understanding of key aspects of stochastic modelling;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a reasonable level of skill in calculation and manipulation of the material in the following areas: random walks, discrete and continuous time Markov chains, queues and branching processes;
3 apply key aspects of stochastic modelling in well-defined contexts, showing judgement in the selection and application of tools and techniques.

The intended generic learning outcomes.
On successfully completing the level 6 module students will be able to:
1 manage their own learning and make use of appropriate resources;
2 understand logical arguments, identifying the assumptions made and the conclusions drawn;
3 communicate straightforward arguments and conclusions reasonably accurately and clearly and communicate technical material competently;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make competent use of information technology skills such as online resources (Moodle);
7 communicate technical material competently;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Ross, S.M. (1996) Stochastic Processes. New York, Wiley.
Breuer, L. and Baum, D. (2005) An introduction to Queueing Theory and Matrix-Analytic Methods. Springer, Dordrecht.
Jones, P.W. and Smith, P. (2001) Stochastic Processes: An Introduction. London, Arnold.
Karlin, S., Taylor, H.M. (1998) A First Course in Stochastic Processes. 3rd Edition, Academic Press, London.
Ross, S.M. (1970) Applied Probability Models with Optimization Applications. Holden-Day, San Francisco.
Cox, D.R. and Miller, H.D. (1965) The Theory of Stochastic Processes. Chapman & Hall/CRC.

Pre-requisites

Prerequisite and co-requisite modules
Level 6:
For delivery to students completing Stage 1 before September 2016:
Pre-requisite: MA321 (Calculus and Mathematical Modelling), MA322 (Proofs and Numbers), and either MA323 (Matrices and Probability) and MA306 (Statistics) or MA319 (Probability and Inference for Actuarial Science) and MA326 (Matrices and Computing); MA552 (Analysis), MA553 (Linear Algebra) and either MA629 (Probability and Inference) or MA529 (Probability and Statistics for Actuarial Science 2); or their equivalents.
Co-requisite: None

For delivery to students completing Stage 1 after September 2016:
Pre-requisite: MAST4009 (Probability), MAST4011 (Statistics), MAST4006 (Mathematical Methods 1), MAST4007 (Mathematical Methods 2), either MAST4010 (Real Analysis 1) and MAST4004 (Linear Algebra) or MAST4005 (Linear Mathematics), and MAST5007 Mathematical Statistics; or their equivalents.
Co-requisite: None

Synopsis *

Introduction: Principles and examples of stochastic modelling, types of stochastic process, Markov property and Markov processes, short-term and long-run properties. Applications in various research areas.
Random walks: The simple random walk. Walk with two absorbing barriers. First–step decomposition technique. Probabilities of absorption. Duration of walk. Application of results to other simple random walks. General random walks. Applications.
Discrete time Markov chains: n–step transition probabilities. Chapman-Kolmogorov equations. Classification of states. Equilibrium and stationary distribution. Mean recurrence times. Simple estimation of transition probabilities. Time inhomogeneous chains. Elementary renewal theory. Simulations. Applications.
Continuous time Markov chains: Transition probability functions. Generator matrix. Kolmogorov forward and backward equations. Poisson process. Birth and death processes. Time inhomogeneous chains. Renewal processes. Applications.
Queues and branching processes: Properties of queues - arrivals, service time, length of the queue, waiting times, busy periods. The single-server queue and its stationary behaviour. Queues with several servers. Branching processes. Applications.

Marks on this module can count towards exemption from the professional examination CT4 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA639 Time Series Modelling and Simulation

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	90% Exam, 10% Coursework	
2	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	Kume Dr A
2	Canterbury	Spring	H	15 (7.5)	90% Exam, 10% Coursework	Kume Dr A

Contact Hours

46

Learning Outcomes

The intended subject specific learning outcomes
On successfully completing this module students will be able to:
1 demonstrate systematic understanding of key aspects of time series modelling and simulation;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a reasonable level of skill in calculation and manipulation of the material in the following areas: ARIMA and GARCH time series models including those modelling seasonality, main methods for simulating random variates;
3 apply key aspects of time series modelling in well-defined contexts, showing judgement in the selection and application of tools and techniques.

The intended generic learning outcomes
On successfully completing this module students will be able to:
1 manage their own learning and make use of appropriate resources;
2 understand logical arguments, identifying the assumptions made and the conclusions drawn;
3 communicate straightforward arguments and conclusions reasonably accurately and clearly and communicate technical material competently;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make competent use of information technology skills such as online resources (Moodle);
7 communicate technical material competently;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Enders, W. (2004), Applied Econometric Time Series, New York: Wiley.
Brockwell, P.J., and Davis, R. A. (2002), Introduction to Time Series Analysis and Forecasting, New York: Springer-Verlag.
Morgan, B. J. T. (1984), Elements of Simulation, London: Chapman & Hall/CRC.

Pre-requisites

MA5507 (Mathematical Statistics) or equivalent

Synopsis *

A time series is a collection of observations made sequentially in time. Examples occur in a variety of fields, ranging from economics to engineering, and methods of analysing time series constitute an important area of statistics. This module focuses initially on various time series models, including some recent developments, and provides modern statistical tools for their analysis. The second part of the module covers extensively simulation methods. These methods are becoming increasingly important tools as simulation models can be easily designed and run on modern PCs. Various practical examples are considered to help students tackle the analysis of real data.The syllabus includes: Difference equations, Stationary Time Series: ARMA process. Nonstationary Processes: ARIMA Model Building and Testing: Estimation, Box Jenkins, Criteria for choosing between models, Diagnostic tests.Forecasting: Box-Jenkins, Prediction bounds. Testing for Trends and Unit Roots: Dickey-Fuller, ADF, Structural change, Trend-stationarity vs difference stationarity. Seasonality and Volatility: ARCH, GARCH, ML estimation. Multiequation Time Series Models: Spectral Analysis. Generation of pseudo – random numbers, simulation methods: inverse transform and acceptance-rejection, design issues and sensitivity analysis.

Marks on this module can count towards exemption from the professional examination CT6 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA6507 Mathematical Statistics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	Laurence Dr A

Contact Hours

44

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the level 6 module students will be able to:
1 demonstrate systematic understanding of key aspects of frequentist and Bayesian statistics;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a reasonable level of skill in calculation and manipulation of the material in the following areas: joint, marginal and conditional probability distributions, to derive distributions of transformed random variables, to calculate point and interval estimates of parameters, to perform tests of hypotheses, prior and posterior distributions, conjugate prior, loss function, Bayesian estimators and credible intervals;
3 apply key aspects of frequentist and Bayesian statistics in well-defined contexts, showing judgement in the selection and application of tools and techniques.

The intended generic learning outcomes.
On successfully completing the level 6 module students will be able to:
1 manage their own learning and make use of appropriate resources;
2 understand logical arguments, identifying the assumptions made and the conclusions drawn;
3 communicate straightforward arguments and conclusions reasonably accurately and clearly;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make competent use of information technology skills such as online resources (moodle), internet communication;
7 communicate technical material competently;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development

Method of Assessment

80% examination, 20% coursework

Preliminary Reading

MILLER, I. and MILLER, M. (2014) John E. Freund's Mathematical Statistics with Applications. 8th international edition. Pearson Education, Prentice Hall, New Jersey.
LINDLEY, D.V. and SCOTT, W.F. (1995) New Cambridge Statistical Tables. 2nd edition.
HOGG, R., CRAIG, A. and McKEAN, J. (2003) Introduction to Mathematical Statistics. 6th international edition.
LARSON, H. J. (1982) Introduction to Probability Theory and Statistical Inference. 3rd edition.
SPIEGEL, M. R, SCHILLER, J. and ALU SRINIVASAN, R. (2013) Schaum's Outline of Probability and Statistics. 4th edition.
LEE, P. M. (2012) [for level 6 students] Bayesian Statistics an Introduction. 4th edition. (ebook)

Synopsis *

Probability: Joint distributions of two or more discrete or continuous random variables. Marginal and conditional distributions. Independence. Properties of expectation, variance, covariance and correlation. Poisson process and its application. Sums of random variables with a random number of terms.
Transformations of random variables: Various methods for obtaining the distribution of a function of a random variable — method of distribution functions, method of transformations, method of generating functions. Method of transformations for several variables. Convolutions. Approximate method for transformations.
Sampling distributions: Sampling distributions related to the Normal distribution — distribution of sample mean and sample variance; independence of sample mean and variance; the t distribution in one- and two-sample problems.
Statistical inference: Basic ideas of inference — point and interval estimation, hypothesis testing.
Point estimation: Methods of comparing estimators — bias, variance, mean square error, consistency, efficiency. Method of moments estimation. The likelihood and log-likelihood functions. Maximum likelihood estimation.
Hypothesis testing: Basic ideas of hypothesis testing — null and alternative hypotheses; simple and composite hypotheses; one and two-sided alternatives; critical regions; types of error; size and power. Neyman-Pearson lemma. Simple null hypothesis versus composite alternative. Power functions. Locally and uniformly most powerful tests. Composite null hypotheses. The maximum likelihood ratio test.
Interval estimation: Confidence limits and intervals. Intervals related to sampling from the Normal distribution. The method of pivotal functions. Confidence intervals based on the large sample distribution of the maximum likelihood estimator – Fisher information, Cramer-Rao lower bound. Relationship with hypothesis tests. Likelihood-based intervals.
In addition, for level 6 students:
Bayesian Inference: Prior and posterior distributions, conjugate prior, loss function, Bayesian estimators and credible intervals. Examples of application.

MA6518 Games and Strategy

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	Lemmens Dr B

Contact Hours

40

Learning Outcomes

On successfully completing the module students will be able to:
1 demonstrate systematic understanding of key aspects of game theory;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a reasonable level of skill in calculation and manipulation of the material in the following areas: combinatorial games, two-player zero-sum games, general and multiplayer games, optimal strategies and equilibria in games;
3 apply key aspects of game theory in well-defined contexts, showing judgement in the selection and application of tools and techniques.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1 manage their own learning and make use of appropriate resources;
2 understand logical arguments, identifying the assumptions made and the conclusions drawn;
3 communicate straightforward arguments and conclusions reasonably accurately and clearly;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make competent use of information technology skills such as online resources (Moodle), internet communication;
7 communicate technical material competently;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% examination, 20% coursework

Preliminary Reading

Game Theory: A playful introduction, M. DeVos and D.A. Kent, Student Mathematical Library, vol. 80, Amer. Math. Soc., 2016.
Playing for real: A text on game theory, K. Binmore, Oxford Univ. Press, 2007.

Pre-requisites

Pre-requisite: MAST4004 (Linear Algebra) or MAST4005 (Linear Mathematics)
Co-requisite: None

Synopsis *

Combinatorial games, game trees, strategy, classification of positions. Two-player zero-sum games, security levels, pure and mixed strategies, von Neumann's minimax theorem. Solving zero-sum two player games using linear programming. Arbitrary sum games, utility, and matrix games. Nash equilibrium, Nash equilibrium theorem, applications, and cooperation. Multi-player games, coalitions, and the Shapley value.

MA715 Financial Mathematics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	Millett Mr J

Contact Hours

48 hours of Lectures and Examples classes.

Learning Outcomes

On successful completion of the module, students will be able to:

a. Describe how to use a generalized cashflow model to descried financial transactions, making allowances for the probability of payment.
b. Describe how to take into account the time value of money using the concepts of compound interest and discounting.
c. Show how interest rates or discount rates may be expressed in terms of different time periods.
d. Demonstrate a knowledge and understanding of real and money interest rates
e. Calculate the present value and the accumulated value of a stream of equal or unequal payments using specified rates of interest and the net present value at a real rate of interest, assuming a constant rate of inflation.
f. Define and use the more important compound interest functions including annuities certain.
g. Define an equation of value.
h. Describe how a loan may be repaid by regular instalments of interest and capital.
i. Show how discounted cashflow techniques can be used in investment project appraisal.
j. Describe the investment and risk characteristics of typical assets available for investment purposes.
k. Analyse elementary compound interest problems.
l. Calculate the delivery price and the value of a forward contract using arbitrage free pricing methods
m. Show an understanding of the term structure of interest rates.
n. Show an understanding of simple stochastic interest rate models.
o. Appreciate recent developments in Financial Mathematics and the links between the theory of Financial Mathematics and their practical application

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Adams, A. T., et al, Investment mathematics – (Wiley 2003)
McCutcheon, J. J., Scott, W. F., An introduction to the Mathematics of Finance – (Institute of actuaries, Faculty of Actuaries in Scotland 1986)
Garrett S – An introduction to the Mathematics of Finance; a deterministic approach – 2nd edition (Institute and faculty of Actuaries 2013)

Synopsis *

The aim of this module is to provide a grounding in financial mathematics and its simple applications. The idea of interest, which may be regarded as a price for the use of money, is fundamental to all long-term financial contracts. The module deals with accumulation of past payments and the discounting of future payments at fixed and varying rates of interest; it is fundamental to the financial aspects of Actuarial Science. The syllabus will cover: Generalised cashflow models, the time value of money, real and money interest rates, discounting and accumulating, compound interest functions, equations of value, loan schedules, project appraisal, investments, elementary compound interest problems, arbitrage free pricing and the pricing and valuation of forward contracts, the term structure of interest rates, stochastic interest rate models.

Marks on this module can count towards exemption from the professional examination CT1 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA726 Finance & Financial Reporting

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
3	Canterbury	Autumn and Spring	H	15 (7.5)	80% Exam, 20% Coursework	Wood Mr N

Contact Hours

36 Hours in Autumn term - 2 lectures and 1 class per week
24 Hours in Spring term - combined lectures/examples and 10 hours optional revision sessions

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the theory
b. to show a comprehensive understanding of the complex techniques applicable to solve problems
c. to appreciate recent developments and methodologies in corporate finance and financial accounting and the links between the financial theories and their practical application and to critically evaluate such methodologies

The intended generic learning outcomes
On successful completion of the Module, students will have:
a. developed a logical mathematical approach to solving complex problems including cases where information/data is not complete
b. developed skills in written communication to both technical and non-technical audiences,
c. developed skills in the use of relevant information technology,
d. developed skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Preliminary Reading

Anne Britton, Christopher Waterston, Financial Accounting
Richard A Brealey Principles of Corporate Finance
JM Samuels, FM Wilkes, RE Brayshaw Management of Company Finance
Geoffrey Holmes, Alan Sugden Interpreting Company Reports and Accounts

Synopsis *

This module provides an introduction to the principles of corporate finance and financial reporting. It is intended for students of Finance and Actuarial Science and is available to students in other programmes where a basic knowledge of financial markets, financial accounting and reporting is needed.
The syllabus introduces and develops the concepts and elements of corporate finance including a knowledge of the instruments used by companies to raise finance and manage financial risk, introduces the concepts and techniques of financial accounting and enables students to understand and interpret critically financial reports of companies and financial institutions including financial statements used by pension funds and insurance companies.

MA7503 Communicating Mathematics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	100% Coursework	Waterstraat Dr N

Contact Hours

Up to 8 hours with project supervisor, 12 workshops

Learning Outcomes

On successfully completing the level 7 module students will be able to:
1 convey a systematic understanding of a topic in mathematics, statistics or financial mathematics through scientific writing and oral presentation;
2 demonstrate a very good level of skill in written and oral presentation of a topic in mathematics, statistics or financial mathematics;
3 show good judgement in the selection and presentation of material to communicate with both specialist and non-specialist audiences.

On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 communicate arguments confidently with the effective and accurate conveyance of conclusions;
2 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
4 make effective use of information technology skills such as word-processing and online resources (Moodle);
5 communicate technical and non-technical material competently;
6 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

100% coursework

Preliminary Reading

Stephen G. Krantz,, A Primer of Mathematical Writing, A.M.S., 1997.
Kevin Houston, How to think like a mathematician: a companion to undergraduate mathematics, C.U.P., 2009.
Hilary Glasman-Deal, Science Research Writing for Non-Native Speakers of English, Imperial College Press, 2009.
Anne E. Greene, Writing science in plain English, University of Chicago Press, 2013.
Alan Beardon, Creative Mathematics: a gateway to research, C.U.P., 2009.
Carmine Gallo, Talk Like TED : The 9 Public Speaking Secrets of the World's Top Minds, Macmillan, 2014.
Toby Oetiker, The not so short introduction to LaTeX, available online, 1995.

Synopsis *

The aim of this module is to equip students with the skills needed to communicate efficiently the findings of a recent piece of research. This module is supported by a series of workshops covering various forms of written and oral communication. Each student will chose a topic in mathematics, statistics or financial mathematics from a published list on which to base their three coursework assessments which include a scientific writing assessment and an oral presentation.

MA7510 Advances in Statistics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	80% Coursework, 20% Exam	Bentham Dr J
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	Bentham Dr J

Contact Hours

40

Learning Outcomes

The intended subject specific learning outcomes:
On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of some selected topics within modern statistics;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material the following areas: modern statistical modelling and statistical methods;
3 apply a range of concepts and principles in some selected topics within modern statistics in loosely defined contexts, showing good judgment in the selection and application of tools and techniques;
4 make effective and well-considered use of R

The intended generic learning outcomes:
On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make effective use of information technology skills such as online resources (moodle), internet communication;
7 communicate technical and non-technical material effectively;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% examination, 20% coursework

Preliminary Reading

The reading list will depend on the topics offered; for the example topics the list is:
a) Statistical Ecology
McCrea, R. S. and Morgan, B. J. T. (2014): Analysis of capture-recapture data (Chapman & Hall / CRC)
b) Survival Analysis
Collet, D. (2003): Modelling survival data in medical research, Second Edition (Chapman & Hall / CRC)
c) Regression models with many variables
Hastie, T., Tibshirani, R. and Wainwright, M. J. (2015): Statistical Learning with Sparsity (Chapman & Hall / CRC).
d) Modern nonparametric statistics
Larry Wasserman (2006): All of Nonparametric Statistics, Springer: New York.

Synopsis *

Each year three topics will be offered and will reflect recent advances in statistical modelling and statistical methodology. Example topics are:
a) Statistical Ecology: Understanding demographic parameters and how they are used to model population dynamics. Estimating abundance and the effect of heterogeneity. Models for estimating survival probabilities. Multi-site and multi-state models. Classical model-selection. Complex models. Case studies.
b) Survival analysis: Survival data, types of censoring. Failure times and hazard functions; Accelerated failure time model. Parametric models, exponential, piecewise exponential, Weibull. Nonparametric estimates: the Kaplan-Meier estimator, and asymptotic confidence regions. Parametric inference. Survival data with covariates. Proportional hazards. Cox's model and inference. Computer software: R and WinBUGS.
c) Regression models with many variables: Examples of high-dimensional problems; Penalized maximum likelihood; Ridge regression; non-negative garrote; Lasso and adaptive Lasso estimation; LARS algorithm; Oracle property; Elastic Net; Group lasso.
d) Modern nonparametric statistics: Bias-variance trade-off, Kernel density estimation, Kernel smoothing, Locally linear and locally quadratic estimation, basis function methods.
In addition, level 7 students will study advanced applications of these techniques (often using R) in all topics.

MA7515 Discrete Mathematics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	Woodcock Dr C

Contact Hours

40

Learning Outcomes

The intended subject specific learning outcomes:
On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of the theory and practice of finite fields and their application to Latin squares, cryptography, m-sequences, cyclic codes and further error-correcting codes;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: modular arithmetic, factorising polynomials, construction of finite fields, Latin squares, classical and public key ciphers including RSA, m-sequences, cyclic codes and further error correcting codes including BCH codes;
3 apply a range of concepts and principles of discrete mathematics in loosely defined contexts, showing good judgment in the selection and application of tools and techniques.

The intended generic learning outcomes:
On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions ;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make effective use of information technology skills such as online resources (Moodle), internet communication;
7 communicate technical material effectively;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% examination, 20% coursework

Preliminary Reading

N L Biggs, Discrete Mathematics, Oxford University Press, 2nd edition, 2002
D Welsh, Codes and Cryptography, Oxford University Press, 1988
R Hill, A First Course in Coding Theory, Oxford University Press, 1980

Synopsis *

Discrete mathematics has found new applications in the encoding of information. Online banking requires the encoding of information to protect it from eavesdroppers. Digital television signals are subject to distortion by noise, so information must be encoded in a way that allows for the correction of this noise contamination. Different methods are used to encode information in these scenarios, but they are each based on results in abstract algebra. This module will provide a self-contained introduction to this general area of mathematics.
Syllabus: Modular arithmetic, polynomials and finite fields. Applications to
• orthogonal Latin squares,
• cryptography, including introduction to classical ciphers and public key ciphers such as RSA,
• "coin-tossing over a telephone",
• linear feedback shift registers and m-sequences,
• cyclic codes including Hamming,
In addition, for level 7 students: applications to further error-correcting codes including BCH codes.

MA7522 Integrable Systems

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	Wang Dr JP

Contact Hours

40

Learning Outcomes

The intended subject specific learning outcomes:
On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of integrable systems;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: nonlinear differential equations, Hamiltonian systems, nonlinear difference equations;
3 apply a range of concepts and principles in integrable systems in various different contexts, showing good judgment in the selection and application of tools and techniques.

The intended generic learning outcomes:
On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make effective use of information technology skills such as online resources (Moodle) and internet communication;
7 communicate technical material effectively;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% examination, 20% coursework

Preliminary Reading

O. Babelon, D. Bernard and M. Talon, Introduction to Classical Integrable Systems, Cambridge Monographs on Mathematical Physics, Cambridge University Press, 2003.
M.J. Ablowitz and P.A. Clarkson, Solitons, Nonlinear Evolution Equations and Inverse Scattering, London Mathematical Society Lecture Note Series 149, Cambridge University Press, 1992.
P.G. Drazin and R.S. Johnson, Solitons: an introduction, Cambridge Texts in Applied Mathematics 2, Cambridge University Press, 1989.
J. Hietarinta, N. Joshi and F. W. Nijhoff, Discrete Systems and Integrability, Cambridge Texts in Applied Mathematics, Cambridge University Press, 2016.

Synopsis *

Integrable systems are special dynamical systems which can be solved exactly in some sense. They arise in a variety of settings, ranging from Hamiltonian systems and nonlinear wave equations to difference equations. This module covers the origins of the subject as well as modern topics like integrable maps and lattice equations.
- Liouville integrability in classical mechanics. Hamiltonian mechanics. Canonical symplectic form and Poisson brackets. Liouville's theorem (statement and examples). Lax pairs for finite-dimensional systems.
- Soliton equations. History and physical origins (e.g. Korteweg-de Vries and/or sine-Gordon). Conservation laws. Hamiltonian formalism. Lax pairs.
- Construction of solitons. Introduction to inverse scattering. Darboux-Bäcklund transformations. Hirota's method.
- Discrete integrability. Symplectic maps. Liouville's theorem (discrete version). Integrable lattice equations. Discrete Lax pairs with examples.
- Additional material for level 7 students (1 week). An extra topic in soliton theory/discrete integrability, such as: further inverse scattering, 3D consistency of lattice equations.

MA7524 Metric and Normed Spaces

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

40

Learning Outcomes

On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of the theory of metric and normed spaces;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: convergence and continuity of maps in metric spaces, contraction mappings, completeness of spaces, spaces of continuous functions, linear operators;
3 apply a range of concepts and principles in metric space theory and the theory of functions in loosely defined contexts, showing good judgment in the selection and application of tools and techniques.

On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make effective use of information technology skills such as online resources (Moodle), internet communication;
7 communicate technical material effectively;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% examination, 20% coursework

Preliminary Reading

G. Cohen: A Course in Modern Analysis and its Applications. Cambridge University Press (2003).
J.R. Giles: Introduction to the Analysis of Normed Linear Spaces. Cambridge University Press (2000).
V.L. Hansen: Functional Analysis – Entering Hilbert Space. World Scientific (2006).
B. Rynne, M. Youngson: Linear Functional Analysis. Springer (2008).
W.A. Sutherland: Introduction to Metric and Topological Spaces. Oxford University Press (2002).
R.L. Devaney: An introduction to chaotic dynamical systems. Second edition. Addison-Wesley Studies in Nonlinearity. Addison-Wesley Publishing Company, Advanced Book Program, Redwood City, CA, 1989.
S. Shirali, H.L. Vasudeva: Metric Spaces. Springer, London (2006).

Synopsis *

Many fundamental concepts and results in mathematical analysis in real and complex spaces rely on the notion of `being close'. It turns out that one can do mathematical analysis in a much wider context as long as there is a distance (or metric) that provides a way to measure closeness. Such spaces are called metric spaces and include the important class of normed spaces. In this module you will be introduced to theory and applications of metric and normed spaces. Much of the theory was developed in the previous century and has been a driving force in modern analysis. As more advanced topics we might discuss the extension of continuous functions from subsets to the whole space, famous fixed point theorems and the astonishing existence of continuous functions which are nowhere differentiable.

MA7529 Statistical Learning

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	80% Coursework, 20% Exam	Matechou Dr E
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	Matechou Dr E

Contact Hours

36

Learning Outcomes

The intended subject specific learning outcomes:
On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of multivariate statistics and machine learning;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: multivariate statistics, mixture modelling and clustering, discriminant analysis and graphical models;
3 apply a range of concepts and principles in multivariate statistics and machine learning in loosely defined contexts, showing good judgment in the selection and application of tools and techniques;
4 make effective and well-considered use of R.

The intended generic learning outcomes:
On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make effective use of information technology skills such as online resources (Moodle), internet communication;
7 communicate technical and non-technical material effectively;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% examination, 20% coursework

Preliminary Reading

D. F. Morrision (1990). Multivariate Statistical Methods, McGraw-Hill Series in Probability and Statistics
T. Hastie, R. Tibshirani and J. H. Friedman (2009). The Elements of Statistical Learning, Spring-Verlag.
K. P. Murphy (2012). Machine Learning: A Probabilistic Perspective, MIT Press.

Synopsis *

Multivariate normal distribution, Inference from multivariate normal samples, principal component analysis, mixture models, factor analysis, clustering methods, discrimination and classification, graphical models, the use of appropriate software.

MA772 Analysis of Variance

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	
1	Canterbury	Autumn	H	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

48, 36 lectures and 12 computer classes

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of the module students will have:
a. a reasonable knowledge of analysis of variance and its application to a
variety of different models.
b. a reasonable knowledge of the basic principles of experimental design.
c. a reasonable ability to do analysis of variance calculations with a computer, and to interpret the resulting output.
d. a reasonable understanding of the inter-relationship between the design of a study and its subsequent analysis.
e. some appreciation of the relevance experimental design and analysis to real world problems.

The Intended Generic Learning Outcomes. On successful completion of this module, students will have
a. developed their understanding of probability and statistics
b. applied a range of mathematical techniques to solve statistical problems.
c. developed their ability to abstract the essentials of problems and to formulate them mathematically.
d. improved their key skills in numeracy, written communication and problem solving
e. enhanced their study skills and ability to work with relatively little supervision.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

NR Draper and H Smith Applied Regression Analysis, Wiley, 3rd ed., 1998 (R)
AM Dean and D Voss Design and Analysis of Experiments, Springer, 1999 (B)
GM Clarke and RE Kempson Introduction to the Design and Analysis of Experiments, Arnold, 1997 (R)

Pre-requisites

Probability and Inference (MA629), Regression Models (MA632); Linear Algebra (MA553) is strongly recommended.

Synopsis *

Analysis of variance is a fundamentally important method for the statistical analysis of data. It is used widely in biological, medical, psychological, sociological and industrial research when we wish to compare more than two treatments at once. In analysing experimental data, the appropriate form of analysis of variance is determined by the design of the experiment, and we shall therefore discuss some aspects of experimental design in this module. Lectures are supplemented by computing classes which explore the analysis of variance facilities of the statistical package R. Syllabus: One-way ANOVA (fixed effects model); alternative models; least squares estimation; expectations of mean squares; distributional results; ANOVA table; follow-up analysis; multiple comparisons; least significant difference; confidence intervals; contrasts; orthogonal polynomials; checking assumptions; residual plots; Bartlett's test; transformations; one-way ANOVA (random effects model); types of experiment; experimental and observational units; treatment structure; randomisation; replication; blocking; the size of an experiment; two-way ANOVA; the randomised complete block design; two-way layout with interaction; the general linear model; matrix formulation; models of full rank; constraints; motivations for using least squares; properties of estimators; model partitions; extra sum of squares principle; orthogonality; multiple regression; polynomial regression; comparison of regression lines; analysis of covariance; balanced incomplete block designs; Latin square designs; Youden rectangles; factorial experiments; main effects and interactions.

MA776 Groups and Representations

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	Bowman Dr C

Contact Hours

42 hours of lectures and classes

Learning Outcomes

On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of the theory and practice of groups (with examples including permutation groups and matrix groups, and the combinatorics of the symmetric group), of linear algebra, and of representations and characters of groups.
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: calculations within permutation groups and matrix groups; computations of the character tables of small groups; derivation of structural information about a group from its character table; formulation and proof of simple statements about groups and representations in precise abstract algebraic language; breaking up representations into smaller simpler objects; composition series and composition factors of small groups.
3 apply a range of concepts and principles in group theory and representation theory in loosely defined contexts, showing good judgment in the selection and application of tools and techniques.

On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed
2 demonstrate a high level of capability in developing and evaluating logical arguments
3 communicate arguments confidently with the effective and accurate conveyance of conclusions
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working
5 solve problems relating to qualitative and quantitative information
6 make effective use of information technology skills such as online resources (moodle) and internet communication.
7 communicate technical material effectively
8 demonstrate an increased level of skill in numeracy and computation.
9 demonstrate the acquisition of the study skills needed for continuing professional development

Method of Assessment

80% examination and 20% coursework.

Preliminary Reading

We will not follow a single text, and the lecture notes will cover the entire syllabus. Nevertheless
G.D. James and M. Liebeck, Representations and characters of groups, CUP (2001)
J.P. Serre, Linear representations of finite groups, Springer GTM (1977)
J.L. Alperin and R.B. Bell, Groups and Representations, Springer GTM (1995)
contain a large amount of the material.

Pre-requisites

Pre-requisite: Students are expected to have studied introductory courses on linear algebra and groups.
Co-requisite: None

Synopsis *

Groups arise naturally in many areas of mathematics as well as in chemistry and physics. A concrete way to approach groups is by representing them as a group of matrices, in which explicit computations are easy. This approach has been very fruitful in developing our understanding of groups over the last century. It also helps students to understand aspects of their mathematical education in a broader context, in particular concepts from earlier modules (From Geometry to Algebra/Groups and Symmetries and Linear Algebra) have been amalgamated into more general and powerful tools.

This module will provide a rigorous introduction to the main ideas and notions of groups and representations. It will also have a strong computational strand: a large part of the module will be devoted to explicit computations of representations and character tables (a table of complex numbers associated to any finite group).

Syllabus:
1. Review of basic group theory (including matrix groups, the symmetric groups, permutation groups and symmetry groups, subgroups, conjugacy, normal subgroups and quotient groups, homomorphisms, group actions);
2. A concrete approach to groups via representations (including examples via group actions and the language modules);
3. Irreducible representations, Maschke's theorem, Schur's lemma;
4. Characters and their basic properties;
5. Character tables: theory and computations for small groups. Consequences.
In addition, for level 7 students:
6. Simple groups, composition series and the Jordan--Hölder theorem.

MA781 Practical Multivariate Analysis

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	70% Exam, 30% Coursework	
1	Canterbury	Spring	H	15 (7.5)	70% Exam, 30% Project	

Contact Hours

This module is organised in conjunction with the Multivariate Analysis (MA079) course which is a compulsory part of the MSc in Statistics. Students will attend about 18 lectures, with computer-based illustrations included as appropriate rather than treated separately. The remainder of the work will be arranged on an individual basis.

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of the module students
– will appreciate the range of multivariate techniques currently available,
– will be able to summarise and interpret multivariate data,
– will have a clear understanding of the logical link between multivariate techniques and corresponding univariate techniques, where appropriate,
– will be able to use multivariate techniques appropriately,
– will appreciate the opportunities for using statistical techniques of multivariate analysis to summarise and interpret complex sets of data,
– will be able to undertake standard multivariate hypothesis tests, and draw appropriate conclusions.

The Intended Generic Learning Outcomes. On successful completion of the module, students
– will have further developed a logical, mathematical approach to solving problems,
– will have enhanced their ability to work with relatively little guidance,
– will have gained further organisational and study skills.
On successful completion of the module, students will also have improved their key skills in written communication, numeracy, problem solving and information technology.

Method of Assessment

70% Examination, 30% Coursework

Preliminary Reading

KV Mardia, JE Kent and JM Bibby Multivariate Analysis, Academic Press, London, 1979
C Chatfield and AJ Collins Introduction to Multivariate Analysis, Chapman and Hall, 1980
DF Morrison Multivariate statistical methods, 4th ed., Duxbury, 2005

Pre-requisites

MA629, MA632

Synopsis *

This module considers statistical analysis when we observe multiple characteristics on an experimental unit. For example, a sample of students' marks on several exams or the genders, ages and blood pressures of a group of patients. We are particularly interested in understanding the relationships between the characteristics and differences between experimental units. Outline syllabus includes: measure of dependence, principal component analysis, factor analysis, canonical correlation analysis, hypothesis testing, discriminant analysis, clustering, scaling.

MA790 Symmetry Methods for Differential Equations

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	Mansfield Prof E

Contact Hours

40-42

Learning Outcomes

On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of techniques for finding and using Lie point symmetries to obtain exact solutions of given equations.
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: calculation of Lie point symmetry generators, canonical coordinates and differential invariants; identification of invariant solutions; successive reduction of order, where the Lie algebra is solvable; construction of the general solution of a given ordinary differential equation; advanced uses of Lie symmetries.
3 apply a range of concepts and principles in Lie symmetry methods in loosely defined contexts, showing good judgment in the selection and application of tools and techniques

On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed
2 demonstrate a high level of capability in developing and evaluating logical arguments
3 communicate arguments confidently with the effective and accurate conveyance of conclusions
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working
5 solve problems relating to qualitative and quantitative information
6 make effective use of information technology skills such as using online resources (Moodle).
7 extend their existing knowledge of mathematics into new areas through independent study
8 communicate technical material effectively
9 demonstrate an increased level of skill in numeracy and computation
10 demonstrate the acquisition of the study skills needed for continuing professional development

Method of Assessment

80% examination and 20% coursework.

Preliminary Reading

P. E. Hydon, Symmetry Methods for Differential Equations, Cambridge University Press, (2000).
H. Stephani, Differential Equations: Their Solution Using Symmetries, Cambridge University Press, (1989).
G. W. Bluman and S. C. Anco, Symmetry and Integration Methods for Differential Equations, Springer, (2002)

Pre-requisites

Pre-requisite modules: Students are expected to have studied material equivalent to that covered in the modules above.
Co-requisite modules: None

Synopsis *

Over a century ago, the Norwegian mathematician Sophus Lie made a simple but profound observation: each well-known method for solving a class of ordinary differential equations (ODEs) uses a change of variables that exploits symmetries of the class. Lie went on to develop this idea into a systematic method for attacking the problem of solving unknown differential equations. Essentially, one can use mathematical tools to force a given differential equation to reveal whether or not it has certain symmetries – provided it has, they can be used to simplify or solve the equation. This module is designed to enable students to understand the mathematics behind Lie's methods and to become proficient in using these powerful tools.
The following topics are covered.
Introduction: Symmetries of geometrical objects, symmetries of some first-order ODEs, solution via symmetries.
Lie symmetries of first-order ODEs: The infinitesimal generator, canonical coordinates, invariant points, Lie symmetries and standard solution methods.
How to find Lie symmetries: The linearized symmetry condition, solution of overdetermined systems, the Lie algebra of point symmetry generators.
Solution of higher-order ODEs: Solvability, differential invariants, reduction of order, invariant solutions.
In addition, for level 7 students:
Advanced topic: This will be selected from the following:
• Symmetry methods for PDEs.
• First integrals and dynamical symmetries.
• Discrete symmetries of ODEs
• Symmetries of difference equations.

MA791 Linear and Nonlinear Waves

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	Clarkson Prof P

Contact Hours

40-42

Learning Outcomes

On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of linear and nonlinear PDEs;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: Fourier transforms for linear differential equations, shock waves, exact solutions of nonlinear PDEs;
3 apply a range of concepts and principles in PDEs in loosely defined contexts, showing good judgment in the selection and application of tools and techniques;
4 make effective and well-considered use of MAPLE.

On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make effective use of information technology skills such as using online resources (Moodle);
7 demonstrate an increased level of skill in numeracy and computation.

Method of Assessment

80% examination and 20% coursework.

Preliminary Reading

M.J. Ablowitz, Nonlinear Dispersive Waves, Cambridge (2011)
J. Bellingham and A.C. King, Wave Motion, Cambridge (2000)
P.G. Drazin and R.S. Johnson, Solitons: an Introduction, Cambridge (1989)
R. Knobel, An Introduction to the Mathematical Theory of Waves, A.M.S. (2000)
J.D Logan, An Introduction to Partial Differential Equations, Wiley (1994)
I.N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill (1957)

Pre-requisites

Pre-requisite: Students are expected to have studied material equivalent to that covered in the modules above.
Co-requisite: None

Synopsis *

Linear PDEs. Dispersion relations. Review of d'Alembert's solutions of the wave equation.
Quasi-linear first-order PDEs. Total differential equations. Integral curves and integrability conditions. The method of characteristics.
Shock waves. Discontinuous solutions. Breaking time. Rankine-Hugoniot jump condition. Shock waves. Rarefaction waves. Applications of shock waves, including traffic flow.
General first-order nonlinear PDEs. Charpit's method, Monge Cone, the complete integral.
Nonlinear PDEs. Burgers' equation; the Cole-Hopf transformation and exact solutions. Travelling wave and scaling solutions of nonlinear PDEs. Applications of travelling wave and scaling solutions to reaction-diffusion equations. Exact solutions of nonlinear PDEs. Applications of nonlinear waves, including to ocean waves (e.g. rogue waves, tsunamis).
Level 7 Students only. Further applications of shock waves and nonlinear waves.

MA792 Operators and Matrices

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	Waterstraat Dr N

Contact Hours

40-42

Learning Outcomes

On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of the theory of linear operators;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: Hermitian matrices and their spectral properties, Hilbert spaces, linear operators and functionals, compact operators, spectral theory;
3 apply a range of concepts and principles in Hilbert space theory and operator theory in loosely defined contexts, showing good judgment in the selection and application of tools and techniques.

On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 communicate technical material effectively;
7 demonstrate an increased level of skill in numeracy and computation;
8 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% examination and 20% coursework.

Preliminary Reading

J.R. Giles: Introduction to the Analysis of Normed Linear Spaces. Cambridge University Press (2000).
V.L. Hansen: Functional Analysis – Entering Hilbert Space. World Scientific (2006).
R. Horn , C. Johnson: Matrix Analysis. Cambridge University Press (1985).
C.D. Meyer: Matrix Analysis and Applied Linear Algebra. SIAM (2000).
B. Rynne, M. Youngson: Linear Functional Analysis. Springer (2008).
G. Strang: Linear Algebra and its Applications, 3rd edition. Saunders (1988).
N. Young: An Introduction to Hilbert space. Cambridge University Press (1988).
F. Zhang: Matrix Theory – Basic Results and Techniques. Springer (2011).

Pre-requisites

Pre-requisite: Students are expected to have studied material equivalent to that covered in the modules above.
Co-requisite: None

Synopsis *

Matrix theory: Hermitian and symmetric matrices, spaces of these matrices and the associated inner product, diagonalization, orthonormal basis of eigenvectors, spectral properties, positive definite matrices and their roots
Hilbert space theory: inner product spaces and Hilbert spaces, L^2 and l^2 spaces, orthogonality, bases, Gram-Schmidt procedure, dual space, Riesz representation theorem
Linear operators: the space of bounded linear operators with the operator norm, inverse and adjoint operators, Hermitian operators, infinite matrices, spectrum, compact operators, Hilbert-Schmidt operators, the spectral theorem for compact Hermitian operators.
Additional topics, especially for level 7 students may include:
- the Rayleigh quotient and variational characterisations of eigenvalues,
- the functional calculus,
- applications to Sturm-Liouville systems.

MA816 Contingencies 1

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	Wood Mr N

Contact Hours

48 hours of Lectures and classes

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a) Define simple assurance and annuity contracts, and develop formulae for the means and variances of the present values of the payments under these contracts, assuming constant deterministic interest.
b) Obtain expressions in the form of sums/integrals for the mean and variance of the present value of benefit payments under each contract above including cases where premiums are payable more frequently than annually and that benefits may be payable annually or more frequently than annually.
c) Describe practical methods of evaluating expected values and variances of the simple contracts defined in objective a.
d) Describe and calculate, using ultimate or select mortality, net premiums and net premium provisions of simple insurance contracts.
e) Carry out the above for simple insurance contracts involving two lives.

The intended generic learning outcomes. On successful completion of the module students will:

a) have developed a logical mathematical approach to solving problems;
b) have developed skills in written communication, time management and organisation and studying.

Method of Assessment

75% Examination, 25% Coursework

Preliminary Reading

The study notes published by the Actuarial Education Company are recommended. Instructions on how to obtain the notes will be given in class.

The following may be consulted for background reading, but are not required reading.
NL Bowers, HU Gerber, JC Hickman et al. Actuarial mathematics. 2nd ed. Society of Actuaries, 1997. ISBN: 0938959468
WF Scott Life assurance mathematics, Heriot-Watt University, 1999.

Synopsis *

This module introduces the concept of survival models, which model future survival time as a random variable. The concept is combined with the financial mathematics learned in module MA820, making it possible to analyse simple contracts which depend on survival time, such as life insurance and annuities. The syllabus will cover: introduction to survival models including actuarial notation, allowance for temporary initial selection and an overview of the typical pattern of human mortality; formulae for the means and variances of the present values of payments under life insurance and annuity contracts assuming constant deterministic interest; practical methods for evaluating the formulae; description and calculation of net premiums, net premium provisions and mortality profit or loss under simple life insurance and annuity contracts; and extension of the basic concepts to straightforward contracts involving two lives.

Marks on this module can count towards exemption from the professional examination CT5 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA817 Contingencies 2

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	75% Exam, 25% Coursework	Millett Mr J

Contact Hours

36 hours of lectures and classes

Learning Outcomes

The intended subject specific learning outcomes and, as appropriate, their relationship to programme learning outcomes:
On successful completion of the module students will be able to:
a) Describe the calculation, using ultimate or select mortality, of net premiums and net premium reserves for increasing and decreasing benefits and annuities.
b) Describe the calculation of gross premiums and reserves of assurance and annuity contracts.
c) Describe methods which can be used to model cashflows contingent upon competing risks.
d) Describe the technique of discounted emerging costs, for use in pricing, reserving, andassessing profitability.
e) Describe the principal forms of heterogeneity within a population and the ways in which selection can occur.

The intended generic learning outcomes. On successful completion of the module students will:
a) have developed a logical mathematical approach to solving problems;
b) have developed skills in written communication, time management and organisation and studying.

Method of Assessment

75% Examination, 25% Coursework

Synopsis *

Life Contingencies is concerned with the probabilities of life and death. Its practical application requires a considerable sophistication in mathematical techniques to ensure the soundness of many of the biggest financial institutions – life assurance companies and pension funds. This module introduces the actuarial mathematics which is needed for this. The aim of this module (together with MA816 – Contingencies 1) is to provide a grounding in the mathematical techniques which can be used to model and value cash flows dependent on death, survival, or other uncertain risks and cover the application of these techniques to calculate premium rates for annuities and assurances on one or more lives and the reserves that should be held for these contracts. Outline syllabus includes variable benefits and with profits contracts; gross premiums and reserves for fixed and variable benefit contracts; competing risks; pension funds; profit testing and reserves; mortality, selection and standardisation. This module together with module MA816 cover the entire syllabus of the UK Actuarial Profession's subject CT5 – Contingencies

MA819 Business Economics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
4	Canterbury	Spring	M	15 (7.5)	75% Exam, 25% Coursework	James Mr A

Contact Hours

48

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the theory
b. to show a comprehensive understanding of the complex techniques applicable to solve problems
c. to appreciate recent developments and methodologies in economics and the links between economic theory and its practical application in business and to critically evaluate such methodologies

The intended generic learning outcomes. On successful completion of the Module, students will have:
a. developed a logical mathematical approach to solving complex problems including cases where information/data is not complete
b. developed skills in written communication to both technical and non-technical audiences
c. developed skills in the use of relevant information technology
d. developed skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level

Method of Assessment

75% Examination, 25% Coursework

Preliminary Reading

David Begg and Damien Ward, Economics for Business, 2nd Ed. (McGraw Hill)
John Sloman, Kevin Hinde and Dean Garratt, Economic for Business 5th Ed. (Prentice Hall)

Synopsis *

The aim of this module is to introduce students to the core economic principles and how these could be used in a business environment to help decision making and behaviour. The coverage is aimed at giving a coherent coverage of the material suitable for students of finance, where understanding economic concepts and principles is important and also to enable the students to gain exemptions from the actuarial subject Business Economics. The syllabus coverage includes: the working of competitive markets, consumer demand and behaviour, product selection, marketing and advertising strategies, costs of production, production function, revenue and profit, profit maximisation under perfect competition and monopoly, imperfect competition, business strategy, the objectives of strategic management, firms growth strategy, pricing strategies, government intervention, international trade, balance of payment and exchange rates, the role of money and interest rates in the economy, the level of business activity, unemployment, inflation and macroeconomic policy.

Marks on this module can count towards exemption from the professional examination CT7 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA820 Financial Mathematics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	Millett Mr J

Contact Hours

48 hours of Lectures

Learning Outcomes

On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the actuarial theory in the areas of the syllabus listed in Section 13
b. to show a comprehensive understanding of the complex techniques applicable to solve problems in the areas of the syllabus listed in Section 13
c. to appreciate recent developments and methodologies in financial mathematics and the links between the theory of financial mathematics and their practical application and to critically evaluate such methodologies

Method of Assessment

75% Examination, 25% Coursework

Preliminary Reading

Adams, A. T., et al, Investment mathematics – (Wiley 2003)
McCutcheon, J. J., Scott, W. F., An introduction to the Mathematics of Finance – (Institute of actuaries, Faculty of Actuaries in Scotland 1986)
Garrett S – An introduction to the Mathematics of Finance; a deterministic approach – 2nd edition (Institute and faculty of Actuaries 2013)

Synopsis *

The aim of this module is to provide a grounding in financial mathematics and its simple applications. The idea of interest, which may be regarded as a price for the use of money, is fundamental to all long-term financial contracts. The module deals with accumulation of past payments and the discounting of future payments at fixed and varying rates of interest; it is fundamental to the financial aspects of Actuarial Science. The syllabus will cover: Generalised cashflow models, the time value of money, real and money interest rates, discounting and accumulating, compound interest functions, equations of value, loan schedules, project appraisal, investments, elementary compound interest problems, arbitrage free pricing and the pricing and valuation of forward contracts, the term structure of interest rates, stochastic interest rate models.

Marks on this module can count towards exemption from the professional examination CT1 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA825 Survival Models

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	McQuire Mr P

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the actuarial theory
b. to show a comprehensive understanding of the complex techniques applicable to solve problems
c. to appreciate recent developments and methodologies in Survival Models and the links between the theory of Survival Models and their practical application and to critically evaluate such methodologies

The intended generic learning outcomes. On successful completion of the Module, students will have:
a. developed a logical mathematical approach to solving complex problems including cases where information/data is not complete,
b. developed skills in written communication to both technical and non-technical audiences,
c. developed skills in the use of relevant information technology,
d. developed skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Method of Assessment

75% Examination, 25% Coursework

Synopsis *

Calculations in life assurance, pensions and health insurance require reliable estimates of transition intensities/survival rates. This module covers the estimation of these intensities and the graduation of these estimates so they can be used reliably by insurance companies and pension schemes. The syllabus includes the following: Principles of actuarial modelling. Distribution and density functions of the random future lifetime, the survival function and the force of hazard. Estimation procedures for lifetime distributions including censoring, Kaplan-Meier estimate, Nelson-Aalen estimate and Cox model. Statistical models of transfers between states. Maximum likelihood estimators for the transition intensities. Binomial and Poisson models of mortality. Estimation of age-dependent transition intensities. The graduation process. Testing of graduations. Measuring the exposed-to-risk.

Marks on this module can count towards exemption from the professional examination CT4 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA826 Finance & Financial Reporting

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	
2	Canterbury	Autumn and Spring	M	15 (7.5)	75% Exam, 25% Coursework	Wood Mr N

Contact Hours

The module consists of: 36 lectures, 24 classes and 12 optional revision lectures

Learning Outcomes

The intended subject specific learning outcomes.
On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the theory
b. to show a comprehensive understanding of the complex techniques applicable to solve problems
c. to appreciate recent developments and methodologies in corporate finance and financial accounting and the links between the financial theories and their practical application and to critically evaluate such methodologies.

The intended generic learning outcomes.
On successful completion of the Module, students will have:
a. developed a logical mathematical approach to solving complex problems including cases where information/data is not complete
b. developed skills in written communication to both technical and non-technical audiences,
c. developed skills in the use of relevant information technology,
d. developed skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Method of Assessment

75% Examination, 25% Coursework

Preliminary Reading

Richard A Brealey Principles of Corporate Finance
Geoffrey Holmes, Alan Sugden Interpreting Company Reports and Accounts 10th Edition
Anne Britton, Christopher Waterston, Financial Accounting

Synopsis *

This module provides an introduction to the principles of corporate finance, financial reporting, the financial markets and financial institutions. It is intended for students of Finance and Actuarial Science. The syllabus introduces and develops the concepts and elements of corporate finance including a knowledge of the instruments used by companies to raise finance and manage financial risk. It introduces the concepts and techniques of financial accounting and enables students to understand and interpret critically financial reports of companies and financial institutions including financial statements used by pension funds and insurance companies. It also covers the basic techniques non financial organisations use to assess and manage their operational risk and the interaction between risk, return and financing costs.

MA835 Portfolio Theory and Asset Pricing Models

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	75% Exam, 25% Coursework	
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	Nica Dr M

Contact Hours

40 hours lectures

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the actuarial theory
b. to show a comprehensive understanding of the complex techniques applicable to solve problems
c. to appreciate recent developments and methodologies in Financial Economics and the links between the theory of Financial Economics and their practical application and to critically evaluate such methodologies

The intended generic learning outcomes. On successful completion of the Module, students will have:
a. developed a logical mathematical approach to solving complex problems including cases where information/data is not complete,
b. developed skills in written communication to both technical and non-technical audiences,
c. developed skills in the use of relevant information technology,
d. developed skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Method of Assessment

75% Exam, 25% Coursework

Preliminary Reading

Elton, Edwin J; Gruber, Martin Jay, Modern portfolio theory and investment analysis, 5th Edition, Wiley, 1995.

Pre-requisites

MA529 Probability and Statistics for Actuarial Science 2 or MA629 Probability and Inference.

Synopsis *

An investor needs an assortment of tools in their toolkit to weigh up risk and return in alternative investment opportunities. This module introduces various measures of investment risk and optimal investment strategies using modern portfolio theory. Pricing of assets using the classical capital asset pricing model and arbitrage pricing theory are discussed. The theory of Brownian motion is used to analyse the behaviour of the lognormal model of asset prices, which is then compared with the auto-regressive Wilkie model of economic variables and asset prices. Principles of utility theory, behavioural finance and efficient market hypothesis provide the context from an investor's perspective. Outline syllabus includes: Measures of investment risk, Mean-Variance Portfolio Theory, Capital Asset Pricing Model, Arbitrage Pricing Theory, Brownian Motion, Lognormal Model, Wilkie Model, Utility Theory and Stochastic Dominance, Efficient Market Hypothesis and Behavioural Finance.

Marks on this module can count towards exemption from the professional examination CT8 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA836 Stochastic Processes

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	Zhang Prof J (MA)

Contact Hours

36 hours of lectures and classes

Learning Outcomes

Subject-specific learning outcomes:
On successful completion of the module students will have
(a) a systematic understanding of the concepts involved in stochastic modelling,
(b) an in-depth knowledge of the various types of stochastic process (discrete or continuous time, discrete or continuous state space),
(c) a good knowledge of the variety of techniques which can be used to obtain probabilities and distributions arising in stochastic processes,
(d) an advanced ability to solve a variety of practical problems to which stochastic process techniques can be applied.

Generic learning outcomes:
On successful completion of the module, students will have
(a) further developed a logical, mathematical approach to deal with complex problems,
(b) enhanced their ability to work autonomously,
(c) gained further organisational and study skills to a high level.
On successful completion of the module, students will also have improved their key skills in written communication, numeracy and problem solving.

Method of Assessment

75% Examination, 25% Coursework

Preliminary Reading

Ross, S M Stochastic Processes. (Wiley, 1996)
Çinlar, E. Introduction to Stochastic Processes. Englewood Cliffs, Prentice-Hall (1975)
Karlin, S. and Taylor, H. A First Course in Stochastic Processes. New York, Academic {Press (1975)
Breuer, L and Baum, D An introduction to Queueing Theory. Heidelberg, Springer (2005)
Rolski, T., Schmidli, H., Schmidt, V & Teugels, J. Stochastic Processes for Insurance and Finance. New York, Wiley. (1999)

Pre-requisites

Co-requisites: MA319 Probability and Statistics for Actuarial Science and MA629 Probability and Inference or equivalent

Synopsis *

A stochastic process is a process developing in time according to probability rules; for example, models for reserves in insurance companies, queue formation, the behaviour of a population of bacteria, and the persistence (or otherwise) of an unusual surname through successive generations. The module will focus on the idea of a stochastic process, and show how this notion can be combined with probability and matrix to build a stochastic model. It will include coverage of a wide variety of stochastic processes and their applications; random walk; Markov chains; processes in continuous-time such as the Poisson process, the birth and death process and Brownian motion; renewal processes; queues; branching processes; epidemic models.

Marks on this module can count towards exemption from the professional examination CT4 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA837 Mathematics of Financial Derivatives

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	75% Exam, 25% Coursework	
2	Canterbury	Spring	M	15 (7.5)	75% Exam, 25% Coursework	Tapadar Dr P

Contact Hours

40 lectures

Department Checked

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the actuarial theory
b. to show a comprehensive understanding of the complex techniques applicable to solve problems
c. to appreciate recent developments and methodologies in Financial Economics and the links between the theory of Financial Economics and their practical application and to critically evaluate such methodologies.

The intended generic learning outcomes. On successful completion of the Module, students will have:
a. developed a logical mathematical approach to solving complex problems including cases where information/data is not complete.
b. developed skills in written communication to both technical and non-technical audiences,
c. developed skills in the use of relevant information technology,
d. developed skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Method of Assessment

75% Exam, 25% Coursework

Preliminary Reading

Baxter, Martin; Rennie, Andrew, Financial calculus : an introduction to derivative pricing, Cambridge University Press, 1996
Hull, John, Options, futures and other derivatives, 7th Edition, Prentice Hall.

Pre-requisites

MA629 (Probability and Inference)

Synopsis *

This module introduces the main features of basic financial derivative contracts and develops pricing techniques. Principle of no-arbitrage, or absence of risk-free arbitrage opportunities, is applied to determine prices of derivative contracts, within the framework of binomial tree and geometric Brownian motion models. The interplay between pricing and hedging strategies, along with risk management principles, are emphasized to explain the mechanisms behind derivative instruments. Models of interest rate and credit risk are also discussed in this context. Outline syllabus includes: An introduction to derivatives, binomial tree model, Black-Scholes option pricing formula, Greeks and derivative risk management, interest rate models, credit risk models.

Marks on this module can count towards exemption from the professional examination CT8 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA840 Financial Modelling

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	100% Coursework	Millett Mr J

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes and, as appropriate, their relationship to programme learning outcomes
On successful completion of the Module, students will be able to:
a) demonstrate skills in specific actuarial software and information technology (e.g. PROPHET)
b) understand the principles of specific actuarial mathematics techniques
c) develop simple actuarial computer models to solve actuarial problems
d) interpret and communicate the results of the models derived in b).

The intended generic learning outcomes and, as appropriate, their relationship to programme learning outcomes
On successful completion of the Module, students will have developed a logical mathematical approach to solving problems. They will have developed skills in oral and written communication and developed the relevant computing skills.

Method of Assessment

100% coursework

Preliminary Reading

This is primarily a practical module. The majority of the reading will be provided by specificlecture notes.

Restrictions

Synopsis *

This module is split into two parts: 1. An introduction to the practical experience of working with the financial software package, PROPHET, which is used by commercial companies worldwide for profit testing, valuation and model office work. The syllabus includes: overview of the uses and applications of PROPHET, introduction on how to use the software, setting up and performing a profit test for a product , analysing and checking the cash flow results obtained for reasonableness, using the edit facility on input files, performing sensitivity tests , creating a new product using an empty workspace by selecting the appropriate indicators and variables for that product and setting up the various input files, debugging errors in the setting up of the new product, performing a profit test for the new product and analysing the results. 2. An introduction to financial modelling techniques on spreadsheets which will focus on documenting the process of model design and communicating the model's results. The module enables students to prepare, analyse and summarise data, develop simple financial and actuarial spreadsheet models to solve financial and actuarial problems, and apply, interpret and communicate the results of such models.

MA858 Computational Statistics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	Ridout Prof M

Contact Hours

32 hours of lectures and 8 terminal classes

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of the module, students will:
1. Have revised and integrated the main probability and statistical material of a standard undergraduate degree programme.
2. Have encountered a range of complex data.
3. Have an appreciation of probability models may be formulated for atypical data sets.
4. Have a good understanding of how likelihood-based classical procedures operate in practice.
5. Have experience of running a wide range of modern statistical procedures through running computer programs in MATLAB.

The intended generic learning outcomes
On successful completion of the module, students will:
1. Appreciate the importance of computing for modern statistical analysis.
2. Appreciate the breadth and importance of modern statistical methods.
3. Be able to describe a number of practical areas where statistical modelling is of importance.
4. Have enhanced their computer skills.
5. Have improved their ability to communicate effectively, and to work independently.
6. Have improved their skills in numeracy, problem solving, computing and written communication.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

B J T Morgan Applied Stochastic Modelling. (2nd ed., CRC Press) (E)
McCullagh, P. and Nelder, J. A. (1989) Generalized linear models, Chapman and Hall.

Synopsis *

This applied statistics module focusses on problems that occur in the fields of ecology, biology, genetics and psychology. Motivated by real examples, you will learn how to define and fit stochastic models to the data. In more complex situations this will mean using optimisation routines in MATLAB to obtain maximum likelihood estimates for the parameters. You will also learn how construct, fit and evaluate such stochastic models. Outline Syllabus includes: Function optimisation. Basic likelihood tools. Fundamental features of modelling. Model selection. The EM algorithm. Simulation techniques. Generalised linear models.

MA867		Project				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	60 (30)	100% Project	
1	Canterbury	Spring	M	60 (30)	95% Project, 5% Coursework	
2	Canterbury	Spring	M	60 (30)	95% Project, 5% Coursework	Ridout Prof M

Contact Hours

This will involve one-to-one meetings with supervisors. Typically there will be approximately eight such meetings.

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of this module, students
-will be aware of the relationship of the material to background material and to more advanced material;
-will have written a coherent account of an area of Statistics, with particular reference to applications in Finance, as/if appropriate;
-will have performed statistical analyses that show the depth of student understanding of the statistical methods relevant to the topic. This is especially the case for students of Statistics; students of Statistics in Finance may alternatively have demonstrated understanding of the importance of Statistics to Finance. For the last two degrees, these issues will depend on the topic studied;
-will have presented analyses and drawn conclusions with clarity and accuracy;
-will have understood theoretical and practical aspects of analysing statistical data. This is especially true for MSc students in Statistics.

The intended generic learning outcomes. On successful completion of this module, students
-will have developed a logical, mathematical approach to solving complex problems, at an advanced level;
-will have enhanced their ability to work with relatively little guidance, and be able to exercise initiative;
- will have gained further organisational, computer and study skills, and be able to adapt them to new situations;
- will be able to use scientific word processing software, such as LaTex, to present their dissertation;
- will have produced a dissertation that effectively communicates the material to the reader;
- will have demonstrated an ability to evaluate research work critically;
- will have selected material from source texts, either recommended to or found by the student;

Method of Assessment

95% Project, 5% Coursework

Preliminary Reading

There is no general reading list for this module. Literature relevant to specific project topics will be recommended by individual supervisors.

Pre-requisites

There are no specific prerequisites, since the necessary foundation will have been laid by the compulsory parts of the MSc in Statistics or MSc in Statistics with Finance.

Synopsis *

The module, which is compulsory for students of MSc in Statistics and MSc in Statistics with Finance, enables students to undertake an independent piece of work in a particular area of statistics, or statistical finance/financial econometrics and to write a coherent account of the material. A list of possible topics, together with names of Staff willing to supervise these projects, will be circulated to students in the autumn term. A broad range of projectsis available, encompassing both practical data analysis and more methodological work, although projects that are primarily theoretical will typically have obvious practical applications. Students then choose a topic after consultation and agreement with the relevant member of staff. This is done early in the spring term and some preliminary work is done during the spring term, leading to a short presentation at the end of that term. The main part of the project is then undertaken after the examinations in May.

MA881 Probability and Classical Inference

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	Ridout Prof M

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes and, as appropriate, their relationship to programme learning outcomes
On successful completion of this module, students will
1 have a systematic understanding of probability and statistical inference
2 be able to use a comprehensive range of relevant concepts and principles
3 be able to select and apply these to solve advanced problems in probability and statistical inference, using a variety of methods

The intended generic learning outcomes and, as appropriate, their relationship to programme learning outcomes

On successful completion of the module, students will
1 have developed a logical, mathematical approach to their work
2 have developed the ability to solve challenging problems

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Ross, S. (1994). A First Course in Probability, 4th Edition, New York: Prentice-Hall International.
Kendall, M.G. and Stuart, A. (1977-1983). The Advanced Theory of Statistics, 4th Edition, Volume 1 (Distribution Theory) and Volume 2 (Inference and Relationship), London: Griffin.
Casella, G. and Berger, R. L. (2002). Statistical Inference, 2nd Edition, Duxbury.
Feller, W. (1967). An Introduction to Probability Theory and its Application, John Wiley & Sons, Inc.

Synopsis *

This module begins by introducing probability, primarily as a tool that underlies the subsequent material on statistical inference. This includes, for example, various notions of convergence for random variables. Classical statistical inference assumes that data follow a probability model with some unknown parameters, and the main aims are to estimate these parameters and to test hypotheses about them. The focus of the module is to develop general methods of statistical inference that can be applied to a wide range of problems. Outline syllabus includes: probability axioms; marginal, joint and conditional distributions; Bayes theorem; important distributions; convergence of random variables; sampling distributions; likelihood; point estimation; interval estimation; likelihood-ratio, Wald and score tests; estimating equations.

MA882 Advanced Regression Modelling

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	Villa Dr C

Contact Hours

30 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of this module, students
- will have a systematic understanding of regression analysis and analysis of variance, and be able to apply these techniques critically to real world data using statistical packages;
- will be able to interpret the results of analysis, and communicate these clearly and concisely to other statisticians and to non-statisticians;
- will appreciate the limitations of standard regression and analysis of variance models for discrete data, and have a clear understanding of how these models can be generalised so as to be more appropriate for discrete data.

The intended generic learning outcomes. On successful completion of the module, students
- will have developed a logical, mathematical approach to their work
- will be to appropriately manipulate data for regression analysis
- will appreciate the need for techniques used to be appropriate to the type of data available.

Method of Assessment

80% examination and 20% coursework

Preliminary Reading

Draper, N. R., and Smith, H. (1998). Applied Regression Analysis, 3rd ed. New York, Wiley.
McCullagh, P., and Nelder, J. A. (1989). Generalized Linear Models, 2nd ed. London, Chapman and Hall.
Everitt, B.S. (1992). The Analysis of Contingency Tables. London, Chapman and Hall.

Pre-requisites

None

Synopsis *

This module covers regression techniques used to understand the effect of explanatory variables on a response, which may be continuous, ordinal or categorical. Issues including general inference, goodness-of-fit, variable selection and diagnostics will be discussed and the material presented in a data-centred way. Outline Syllabus includes: Linear Model: Simple and multiple linear regression including inference (estimation, hypothesis testing and confidence intervals) and diagnostics (detection of outliers, multicollinearity and influential observations). The General linear model, polynomial regression and analysis of variance. Discrete data analysis: Review of Binomial, Poisson, negative binomial and multinomial distributions. Properties, estimation, hypothesis tests. Generalized Linear Model: Estimation, hypothesis testing and model comparison of these models. Diagnostics and goodness-of-fit. Contingency tables: Tests for independence, Measures of association, logistic models, multidimensional tables, log linear models, fitting and model selection.

MA883 Bayesian Statistics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	Leisen Dr F

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of this module, students
- will be able to derive posterior distributions when analytically tractable;
- will understand how to derive posterior summaries, such as estimates, from the posterior distribution, including the predictive distribution;
- will be able to implement sampling based methods to Bayesian inference, such as the Gibbs sampler, when the posterior distribution is analytically intractable;
- will be able to undertake Bayesian decision theory and model choice;
- will understand the subjective and objective approaches to Bayesian inference.

The intended generic learning outcomes. On successful completion of this module, students
- will have further developed a logical, mathematical approach to solving problems;
- will have enhanced their ability to work with relatively little guidance;
- will have improved their key skills in written communication, numeracy and problem solving.

Method of Assessment

80% examination and 20% coursework

Preliminary Reading

A.F.M. Smith and Bernardo, J.M. (1994). Bayesian Theory. Wiley.
D. Gamerman and H.F. Lopes (2006). Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference. 2nd Edition, Taylor and Francis.

Synopsis *

The origins of Bayesian inference lie in Bayes' Theorem for density functions; the likelihood function and the prior distribution combine to provide a posterior distribution which reflects beliefs about an unknown parameter based on the data and prior beliefs. Statistical inference is determined solely by the posterior distribution. So, for example, an estimate of the parameter could be the mean value of the posterior distribution. This module will provide a full description of Bayesian analysis and cover popular models, such as the normal distribution. Initially, the flavour will be one of describing the Bayesian counterparts to well known classical procedures such as hypothesis testing and confidence intervals. Current methods for inference involving posterior distributions typically involve sampling strategies. That is, due to the complicated nature of some posterior distributions, analytic methods fail to provide meaningful summaries. Hence, sampling from the posterior has become popular. A full description of sampling techniques, starting from rejection sampling, will be given. Outline Syllabus includes: Conjugate models (prior and posterior belong to the same family of parametric models). Predictive distributions; Bayes estimates; Sampling density functions; Gibbs and Metropolis-Hastings samplers; Winbugs; Bayesian regression and hierarchical models; Bayesian model choice; Decision theory; Objective priors; Exchangeability.

MA884 Principles of Data Collection

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	15 (7.5)	80% Exam, 20% Coursework	Laurence Dr A

Contact Hours

40

Learning Outcomes

On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of sampling and experimental design;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: sampling, questionnaire design, analysis of variance, clinical trial design, advanced experimental design;
3 apply a range of concepts and principles in sampling and experimental design in loosely defined contexts, showing good judgment in the selection and application of tools and techniques;
4 make effective and well-considered use of R for the analysis of data from experiments.

On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make effective use of information technology skills such as R, online resources (moodle), internet communication;
7 communicate technical and non-technical material effectively;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% examination and 20% coursework

Preliminary Reading

Barnett, V. (2002) Sample Survey Principles and Methods. 3rd edition. New York, Wiley.
Cox, D.R. (1992) Planning of Experiments. New York, Wiley.
Cochran, W.G. & Cox, G.M. (1992) Experimental Designs. 2nd edition. New York, Wiley.
Cox. D.R & Reid, N. (2000) The Theory of the Design of Experiments. Boca Raton, Chapman & Hall/CRC
Lawson, J. (2015) Design and Analysis of Experiments with R. Boca Raton, Chapman & Hall/CRC.
Matthews, J. N. S. (2000) An Introduction to Randomized Controlled Clinical Trials. 2nd edition. Boca Raton, Chapman & Hall/CRC.

Synopsis *

Sampling: Simple random sampling. Sampling for proportions and percentages. Estimation of sample size. Stratified sampling. Systematic sampling. Ratio and regression estimates. Cluster sampling. Multi-stage sampling and design effect. Questionnaire design. Response bias and non-response.
General principles of experimental design: blocking, randomization, replication. One-way ANOVA. Two-way ANOVA. Orthogonal and non-orthogonal designs. Factorial designs: confounding, fractional replication. Analysis of covariance. Design of clinical trials: blinding, placebos, eligibility, ethics, data monitoring and interim analysis. Good clinical practice, the statistical analysis plan, the protocol. Equivalence and noninferiority. Sample size. Phase I, II, III and IV trials. Parallel group trials. Multicentre trials.
In addition, level 7 students will study hierarchical designs: fixed and random effects models; split-plot designs; crossover trials; variance components.

MA885 Stochastic Processes and Time Series

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	15 (7.5)	90% Exam, 10% Coursework	Zhang Prof J (MA)

Contact Hours

30 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of this module, students
- will have a critical appreciation of the importance of statistics in different areas of current relevance;
- will have an appreciation of actuarial areas of application in which statistical methods play a vital role, and of their importance;
- will have an appreciation of the development of specialised methods of stochastic analysis for actuarial areas of application;
- will be able to synthesise knowledge, and to appreciate links between disparate subject areas;
- will appreciate the need to understand real world contexts in depth, and to devise appropriate stochastic models and methods.

The intended generic learning outcomes. On successful completion of this module, students
- will have a systematic understanding of the role of logical argument;
- will be able to evaluate research work critically;
- will have technical expertise, particularly in relation to financial problems.
- will have improved their key skills in written communication, numeracy and problem solving.

Method of Assessment

90% examination and 10% coursework

Preliminary Reading

L. Breiman (1992) Probability. Philadelphia, PA: SIAM.
E. Cinlar (1975) Introduction to stochastic processes. Englewood Cliffs, N.J.:Prentice- Hal.
L. Breuer and D. Baum (2005) An introduction to queueing theory and matrix-analytic methods. Springer, Heidelberg
S. Karlin and H. M. Taylor (1975) A first course in stochastic processes. 2nd ed., New York: Academic Press.
S. Ross (1970) Applied Probability Models with Optimization Applications. Dover, New York.
S. Ross (1983) Stochastic Processes. John Wiley & Sons, New York
W. Enders (2004) Applied Econometric Time Series New York: Wiley.
P.J. Brockwell and R.A. Davis (2002) Introduction to time series and forecasting. Springer

Pre-requisites

MA881

Synopsis *

This module will focus on basic features of stochastic processes and time series analysis. It includes: Markov chains on discrete state spaces, communication classes, transience and recurrence, positive recurrence, stationary distributions. Markov processes on discrete state spaces, exponential distribution, embedded Markov chain, transition graphs, infinitesimal generator, transition probabilities, stationary distributions, skip-free Markov processes. Stationary time series: Stationarity, autocovariance and autocorrelation functions, partial autocorrelation functions, ARMA processes. ARIMA Model Building and Testing: Estimation, Box Jenkins, criteria for choosing between models, diagnostic tests for the residuals of a time series after estimation. Forecasting: Holt-Winters, Box-Jenkins, prediction bounds.

MA886 Modelling of Time-Dependent Data and Financial Econometrics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
4	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	
5	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	Hadjiantoni Dr S

Contact Hours

38

Learning Outcomes

On successfully completing the level 7 module students will be able to:
1 demonstrate systematic understanding of financial time series data analysis;
2 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: ARIMA and GARCH model building, testing and estimation, model selection, forecasting, financial hypothesis testing and modelling in the context of asset returns, the efficient portfolio;
3 apply a range of concepts and principles in financial time series data analysis in loosely defined contexts, showing good judgement in the selection and application of tools and techniques;
4 make effective and well-considered use of R.

On successfully completing the level 7 module students will be able to:
1 work competently and independently, be aware of their own strengths and understand when help is needed;
2 demonstrate a high level of capability in developing and evaluating logical arguments;
3 communicate arguments confidently with the effective and accurate conveyance of conclusions;
4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;
5 solve problems relating to qualitative and quantitative information;
6 make effective use of information technology skills such as online resources (moodle);
7 communicate technical and non-technical material effectively;
8 demonstrate an increased level of skill in numeracy and computation;
9 demonstrate the acquisition of the study skills needed for continuing professional development;

Method of Assessment

80% examination and 20% coursework

Preliminary Reading

Enders, W. (2004). Applied Econometric Time Series. New York: Wiley.
Brockwell, P.J. & Davis, R.A. (2002). Introduction to Time Series and Forecasting. New York: Springer.
Ruey S. Tsay (2002). Analysis of financial time series, New York: Wiley
Campbell, J.Y., Lo, A.W. and Mackinlay, A.C. (1997). The Econometrics of Financial Markets, New Jersey: Princeton University Press.
Lyuu Y. (2002). Financial Engineering and Computation. Cambridge University Press.

Pre-requisites

Synopsis *

Overview of statistical methods. Stationary time series. Autocovariance and autocorrelation functions. Partial autocorrelation functions. ARMA processes. ARIMA model building, testing and estimation. Criteria for choosing between models. Forecasting. Cointegration. Prediction bounds. Asset return and risk. Term structure of interest rates. Distributional properties of asset returns. Testing for CAPM. Testing random walk hypothesis and predicting asset return. Sharpe ratio and efficient portfolio. Cross-section modelling and GMM. Estimate multifactor models. Financial applications of AR, MA, and ARMA. ARCH and GARCH models. Volatility processes. Simple applications of these techniques using R.
In addition, level 7 students will study advanced applications of these techniques using R.

MA888 Stochastic Models in Ecology and Medicine

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

30 lectures, 3 classes

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of this module, students
- will have met a wide range of ecological and medical data sets, and understood how models may be derived for them;
- will have developed the skill of applying modern statistical techniques applicable to ecology and medicine;
- will have experience of modern statistical methods that make use of the power of modern computers, using RMARK and WinBUGS;
- will understand the use of stochastic modelling and the probabilistic concepts involved;

The intended generic learning outcomes. On successful completion of the module, students
- will have an appreciation of the originality required for problem solving, linked to research work taking place at the University of Kent;
- will have experience of the application of scientific computing to solve substantive real world problems;

Method of Assessment

80% examination and 20% coursework

Preliminary Reading

Collett. D. (2003) Modelling Survival Data in Medical Research, Second Edition. Chapman & Hall/CRC, Boca Raton.
Williams, B.K., Nichols, J.D. and Conroy, M.J. (2001) Analysis and Management of Animal Populations. Academic Press, San Diego.
Amstrup, S.C., McDonald, T.L. and Manly, B.F.J. (2005) Handbook of capture-recapture analysis. Princeton University Press.
McCrea, R.S. and Morgan, B.J.T. (2014) Analysis of capture-recapture data. Chapman and hall.CRC Press, Boca Raton.

Synopsis *

This module considers the development and application of stochastic models in two specific areas. The ecological part is focused on the analysis of data collected on wild animals. Particular attention will be given to estimating how long wild animals live, and also to estimating the sizes of mobile animal populations. The medical part also considers the estimation of survival, but in this case for human beings, with less data loss due to individuals leaving the study than is typical in ecological studies. In survival data it is often known only that individuals survived for a certain period of time, with exact survival time being unknown. This is called censoring and its implications will be discussed in detail. Outline Syllabus includes: Estimating abundance; estimating survival; using covariates; multi-state models; parameter redundancy; human survival data with censoring; the hazard and related functions; parametric and semiparametric survival models.

MA889 Analysis of Large Data Sets

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students
- will be able to summarise and interpret multivariate data effectively;
- will have a critical awareness of the logical link between multivariate techniques and corresponding univariate techniques;
- will have a systematic understanding of a wide range of modern techniques in dimension reduction, regarding to their strengths and weakness;
- will be able to use statistical software to apply multivariate techniques and variable selection methods;
- will be able to select and apply these solve practical problems, to undertake
statistical calculations and manipulations, and to communicate the results effectively to statisticians.

The intended generic learning outcomes. On successful completion of the module students
- will have developed mathematical, critical approach to their work;
- will have developed the ability to solve practical problems.
- will have improved their key skills in numeracy, problem solving and information technology.

Method of Assessment

80% examination and 20% coursework

Preliminary Reading

K. V. Mardia, J. T. Kent, and J. M. Bibby (1979) Multivariate analysis, London, Academic Press
D. F. Morrison (1990) Multivariate Statistical Method, McGraw-Hill Series in Probability and Statistics.
T. Hastie, R. Tibshirani and J. H. Friedman (2009) The Elements of Statistical Learning, Springer-Verlag.
P. J. Brown (1994) Measurement, Regression and Calibration, Oxford University Press

Synopsis *

This module considers statistical analysis when we observe multiple characteristics on an experimental unit. For example, a sample of students' marks on several exams or the genders, ages and blood pressures of a group of patients. We are particularly interested in understanding the relationships between the characteristics and differences between experimental units. Regression methods can be used if one characteristic can be treated as a response variable and the others as explanatory variables. Variable selection on the explanatory variables can be daunting if the number of characteristics is large and suitable methods will be investigated. Outline Syllabus includes: measure of dependence, principal component analysis, factor analysis, canonical correlation analysis, hypothesis testing, discriminant analysis, clustering, scaling, information criterion methods for variable selection, false discovery rate, penalised maximum likelihood.

MA890 Practical Statistics and Computing

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	15 (7.5)	100% Coursework	Kume Dr A
2	Canterbury	Autumn and Spring	M	15 (7.5)	70% Project, 30% Coursework	Kume Dr A

Contact Hours

55 workshops and lectures

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of this module, students;
- will be proficient in LaTeX for document preparation and the statistical package R;
- will be able to select suitable techniques to analyse data in a sensible way and interpret the results appropriately;
- will be able to provide clear and competent reports on statistical analyses,
- will be able to use suitable nonparametric methods to analyse data.

The intended generic learning outcomes. On successful completion of this module, students
- will be able to plan and implement the analysis of unfamiliar material in a professional way;
- will be able to use information technology effectively for advanced data analysis including data retrieval;
- will be able to use scientific word processing software, such as LaTeX, to present reports on statistical analyses.

Method of Assessment

70% Project, 30% Coursework

Preliminary Reading

We will not follow a single text and the course will be heavily based on the lecture notes. Useful books include the following:
Chatfield, C. (1995) Problem–solving: a statistician's guide. London, Chapman and Hall.
Crawley M. J. (2009) The R Book , Wiley
Cox, D.R. and Snell E.J. (1987) Applied Statistics: Principles and Examples (Chapman Hall statistics text series).
Conover, W. J. (1999) Practical Nonparametric Statistics, 3rd ed. New York, Wiley.

Synopsis *

Nonparametric Methods: This part of the module comprises approximately 10 lectures on nonparametric methods, showing how they are applied in practice for testing goodness of fit to a distribution, including tests of normality, for testing randomness of a sequence, and for comparing two samples. Practical Statistics: There is no fixed syllabus for this component of the course. Students gain experience of practical data analysis through a series of assessments that confront them with unfamiliar data, which may require the use of techniques introduced in any of the other core modules of the Programme. Statistical Computing: At the start of the module, students are introduced to, and gain experience of, the document preparation system LaTeX, which enables the production of high-quality mathematical documents. Then there are sessions in which students learn the statistical package R, using a mixture of lectures and hands-on computing workshops. The initial aim is for students to gain familiarity with importing and manipulating data, producing graphs and tables, and running standard statistical analyses. The later parts of the module focus on the use of R as a programming language, introducing basic programming mechanisms such as loops, conditional statements and functions. This provides students with the means to develop their own code to undertake non-routine types of analysis if these are not already available in R.

MA909 Enterprise Risk Management

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	McQuire Mr P

Contact Hours

72

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Enterprise Risk Management in the context of current professional actuarial practice.
b) Demonstrate knowledge and understanding of complex current issues in Enterprise Risk Management in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of Enterprise Risk Management in various contexts.
f) Demonstrate skill in solving problems in Enterprise Risk Management by various appropriate methods.
g) Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of Enterprise Risk Management and their application to solving problems in that subject.
h) Understanding of the current practical applications of the module material

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument.
b) Demonstrate ability to work with relatively little guidance.
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
d) Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences Using the appropriate information technology.
e) Demonstrate judgemental skills.
f) Demonstrate numeracy and computational skills.
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effect modes of working, and to act autonomously.
h) Demonstrate study skills needed for continuing professional development.
i) Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students are provided with study notes published by the Actuarial Education Company.
The students are provided with the textbook Sweeting (2011) Financial Enterprise Risk Management, Cambridge. The following textbook is also recommended: J Lam (2006) Enterprise Risk Management: From Incentives to Controls, Wiley

Synopsis *

The aim of this module is to introduce the key principles of Enterprise Risk Management ("ERM") within an organisation (e.g. insurance companies, banks, pension schemes). ERM involves the integration of risk management across an organisation, rather than treating each individual risk which an organisation faces separately. Students should gain an understanding of the implementation and application of ERM; as such successful students in MA909 will acquire skills which are applicable to a diverse range of organisations and scenarios. A number of syllabus items are highly technical - students will be introduced to a number of concepts such as copulas and GARCH models, whilst developing concepts introduced under CT6, CT8 and CA1. As such students intending to study this module should be confident with material studied in the CT6 and CT8 syllabuses. Outline syllabus: ERM framework and processes, risk classification, modelling risks and correlations, identifying, measuring and managing risks across an organisation, economic capital, application of quantitative techniques/models such as copulas, extreme value theory, credit risk models, GARCH models.

Marks on this module can count towards exemption from the professional examination ST9 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA912 Life Insurance

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	Alai Dr D

Contact Hours

72 lecture hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Life Insurance in the context of current professional actuarial practice.
b) Demonstrate knowledge and understanding of complex current issues in Life Insurance in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module.
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of Life Insurance in various contexts.
f) Demonstrate skill in solving problems in Life Insurance by various appropriate methods.
g) Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of Life Insurance and their application to solving problems in that subject.
h) Understanding of the current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument.
b) Demonstrate ability to work with relatively little guidance.
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
d) Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences. Using the appropriate information technology.
e) Demonstrate judgemental skills.
f) Demonstrate numeracy and computational skills.
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effect modes of working, and to act autonomously.
h) Demonstrate study skills needed for continuing professional development.
i) Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students are provided with study notes published by the Actuarial Education Company

Synopsis *

This module introduces students to the principles of actuarial planning and control, and mathematical and economic techniques, relevant to life insurance companies. The student should gain the ability to apply the knowledge and understanding, in simple situations, to the operation, on sound financial lines, of life insurance companies. Outline syllabus includes: principal terms used in life insurance; the main types of life insurance products; methods of distributing profits to with profits policyholders including the use of asset shares; effect of the general business environment on a life insurance company; risks to a life insurance company and methods to manage these risks (including the use of reinsurance and underwriting); use of actuarial models for decision making purposes; principles of unit pricing and the technique of actuarial funding for unit linked life insurance contracts; cost of guarantees and options; determining discontinuance and alteration terms for without profits contracts; factors to consider in determining a suitable design for a life insurance product; setting assumptions for pricing and valuing life insurance contracts; determining supervisory reserves; principles of investment for a life insurance company; monitoring actual experience of a life insurance company.

Marks on this module can count towards exemption from the professional examination ST2 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA914 Pensions and Other Benefits

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

72 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Pensions and Other Benefits in the context of current professional actuarial practice.
b) Demonstrate knowledge and understanding of complex current issues in Pensions and Other Benefits in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module.
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of Pensions and Other Benefits in various contexts.
f) Demonstrate skill in solving problems in Pensions and Other Benefits by various appropriate methods.
g) Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of Pensions and Other Benefits and their application to solving problems in that subject.
h) Understanding of the current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument
b) Demonstrate ability to work with relatively little guidance
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought
d) Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences. Using the appropriate information technology
e) Demonstrate judgemental skills
f) Demonstrate numeracy and computational skills
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effect modes of working, and to act autonomously
h) Demonstrate study skills needed for continuing professional development
i) Demonstrate decision-making skills in complex situations

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students are provided with study notes published by the Actuarial Education Company.

Synopsis *

The aim of this module is to develop student's ability to apply, in simple situations, the mathematical and economic techniques and the principles of actuarial planning and control needed for the operation on sound financial lines of providers of pensions or other employee benefits. The syllabus includes: providers of pensions and other benefits, meeting the needs of interested parties; environment in which benefits are provided; scheme design; risk and uncertainties; financing benefits; investment; actuarial valuations – use of models; asset and benefit valuation models; funding methods; assumptions; discontinuance; valuation data; the need for valuations; options and guarantees; asset liability matching; insurance; sources of surplus; analysis of experience.

Marks on this module can count towards exemption from the professional examination ST4 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA915 Finance and Investment

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	Srinivasan Ms V

Contact Hours

72 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Finance & Investment in the context of current professional actuarial practice.
b) Demonstrate knowledge and understanding of complex current issues in Finance & Investment in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module.
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of Finance & Investment in various contexts.
f) Demonstrate skill in solving problems in Finance & Investment by various appropriate methods.
g) Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of Finance & Investment and their application to solving problems in that subject.
h) Understanding of the current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument.
b) Demonstrate ability to work with relatively little guidance.
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
d) Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences.
e) Demonstrate judgemental skills.
f) Demonstrate numeracy and computational skills.
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effect modes of working, and to act autonomously.
h) Demonstrate study skills needed for continuing professional development.
i) Demonstrate decision-making skills in complex situations.
j) Demonstrate the ability to produce written documents; undertake online research; communicate using e-mail.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students are provided with study notes published by the Actuarial Education Company.

Synopsis *

This aim of this module is to introduce students to various financing and investment opportunities available to participants in financial markets. The module covers various different asset classes like to hedge funds, private equity, infrastructure and derivatives pricing and valuation. The module also explores the relationship between investors and investment managers in detail. The concepts of risk and return and the roles of regulators, central banks and governments are also analysed. Outline syllabus includes: the theory of finance, specialist asset classes, influence of regulatory and legislative framework on markets, fundamental analysis, valuation of assets, investment indices, performance measurement, risk control, actuarial techniques, portfolio management and taxation.

Marks on this module can count towards exemption from the professional examination ST5 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA916 Derivative Securities

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	Tapadar Dr P

Contact Hours

72 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Derivative Securities in the context of current professional actuarial practice.
b) Demonstrate knowledge and understanding of complex current issues in Derivative Securities in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module.
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of Derivative Securities in various contexts.
f) Demonstrate skill in solving problems in Derivative Securities by various appropriate methods.
g) Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of Derivative Securities and their application to solving problems in that subject.
h) Understanding of the current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument,
b) Demonstrate ability to work with relatively little guidance,
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought,
d) Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences,
e) Demonstrate judgemental skills,
f) Demonstrate numeracy and computational skills,
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effect modes of working, and to act autonomously,
h) Demonstrate study skills needed for continuing professional development,
i) Demonstrate decision-making skills in complex situations
j) Demonstrate the ability to produce written documents; undertake online research; communicate using e-mail.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students are provided with study notes published by the Actuarial Education Company.
The following textbooks are also recommended: JC Hull:Options, Futures and Other Derivatives 6th Edition (Prentice Hall) (E)
Baxter & Rennie: Financial Calculus (Cambridge University Press 1997) (E)

Restrictions

Synopsis *

This module introduces different financial derivative contracts available in the market, develops pricing techniques and risk management tools to manage risks associated with a portfolio of derivative contracts. Principle of no-arbitrage, or absence of risk-free arbitrage opportunities, is applied to determine prices of derivative contracts, within the framework of binomial tree and geometric Brownian motion models. Interest rate models and interest rate derivatives are discussed in detail. Credit risk models are introduced in the context of pricing defaultable bonds and credit derivatives. Outline syllabus includes: An introduction to derivatives, futures and forward, options and trading strategies, binomial tree model, Black-Scholes option pricing formula, Greeks and derivative risk management, numerical techniques, exotic options, interest rate models and interest rate derivatives, credit risk and credit derivatives.

Marks on this module can count towards exemption from the professional examination ST6 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA917 General Insurance - Reserving and Capital Modelling

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	Jackson Mr A

Contact Hours

72 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a) Demonstrate knowledge and understanding of complex techniques applicable to solve problems in General Insurance Reserving and Capital Modelling in the context of current professional actuarial practice.
b) Demonstrate knowledge and understanding of complex current issues in General Insurance Reserving and Capital Modelling in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module.
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of General Insurance Reserving and Capital Modelling in various contexts.
f) Demonstrate skill in solving problems in General Insurance Reserving and Capital Modelling by various appropriate methods.
g) Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of General Insurance Reserving and Capital Modelling and their application to solving problems in that subject.
h) Understanding of the current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument.
b) Demonstrate ability to work with relatively little guidance.
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
d) Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences using the appropriate information technology.
e) Demonstrate judgemental skills.
f) Demonstrate numeracy and computational skills.
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effect modes of working, and to act autonomously.
h) Demonstrate study skills needed for continuing professional development.
i) Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students are provided with study notes published by the Actuarial Education Company

Synopsis *

The aim of this module is to develop the student's ability to apply, in simple situations, the mathematical and economic techniques and the principles of reserving and capital modelling needed for the operation on sound financial lines of general insurers. Outline syllabus includes: insurance products; reinsurance products; the business environment; Lloyd's; risk and uncertainty; data; actuarial investigations; reserving by triangulation methods; reserving bases; stochastic claims reserving; assessment of reserving results; use of ranges and best estimates in reserving; investment principles and asset liability matching; capital modelling; determining appropriate reinsurance; reserving of reinsurance; accounting principles; interpreting accounts; regulation.

Marks on this module can count towards exemption from the professional examination ST7 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA918 General Insurance - Premium Rating

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	Jackson Mr A

Contact Hours

72 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a) Demonstrate knowledge and understanding of complex techniques applicable to solving problems in General Insurance Premium Rating in the context of current professional actuarial practice.
b) Demonstrate knowledge and understanding of current issues in General Insurance Premium Rating in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module.
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of General Insurance Premium Rating in various contexts.
f) Demonstrate skill in solving problems in General Insurance Premium Rating by various appropriate methods.
g) Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of General Insurance Premium Rating and their application to solving problems in that subject.
h) Understand current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument.
b) Demonstrate ability to work with relatively little guidance.
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
d) Demonstrate written communications skills
e) Demonstrate judgemental skills.
f) Demonstrate numeracy and computational skills.
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effective modes of working, and to act autonomously.
h) Demonstrate study skills needed for continuing professional development.
i) Demonstrate decision-making skills in the context of complex scenarios.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students are provided with study notes published by the Actuarial Education Company.
Knowledge is required of the stochastic models and mathematical methods relevant for general insurance covered in subjects CT4 and CT6 of the Institute and Faculty of Actuaries

Synopsis *

The aim of this module is to develop the student's ability to apply, in simple situations, the mathematical and economic techniques and the principles of premium rating needed for the operation on sound financial lines of general insurers. Outline syllabus includes: insurance products; reinsurance products; the business environment; risk and uncertainty; data; actuarial investigations; risk models; introduction to rating methodologies and bases; rating using frequency-severity and burning cost approaches; rating using original loss curves; generalised linear modelling; use of multivariate analysis in pricing; credibility theory; rate monitoring; pricing of reinsurance; use of catastrophe models.

Marks on this module can count towards exemption from the professional examination ST8 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA921 Actuarial Risk Management 1

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	
4	Canterbury	Autumn	M	30 (15)	80% Exam, 20% Coursework	Rogers Mr I

Contact Hours

72 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate the ability to apply a wide range of key actuarial concepts in simple traditional and non-traditional situations.
b) Demonstrate knowledge and understanding of complex techniques applicable to solve problems using core actuarial concepts in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module.
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of core actuarial concepts in various contexts.
f) Demonstrate skill in solving problems using core actuarial concepts by various appropriate methods.
g) Understanding of the current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument.
b) Demonstrate ability to work with relatively little guidance.
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
d) Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences.
e) Demonstrate judgemental skills.
f) Demonstrate numeracy and computational skills.
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effect modes of working, and to act autonomously.
h) Demonstrate study skills needed for continuing professional development.
i) Demonstrate decision-making skills in complex situations.
j) Demonstrate the ability to produce written documents; undertake online research; communicate using e-mail.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Students will be provided with the textbook, Understanding Actuarial Management: the actuarial control cycle (second edition) edited by Bellis, Lyon, Klugman & Shepherd, The Institute of Actuaries of Australia and the Society of Actuaries, 2010.

Synopsis *

The aim of this module is to develop the student's ability to apply a wide range of key actuarial concepts in simple traditional and non-traditional situations. Outline syllabus includes: stakeholders; providers of benefits; managing risks; marketing; life and general insurance products; regulatory regimes; external environment; project management; capital project appraisal; cashflows of simple products; money, bond, equity and property markets; futures and options; collective investment vehicles; overseas markets; economic influences on investment markets; other factors affecting relative valuation; relationship between returns on asset classes; asset modelling; meeting institutional investor needs; personal investment; valuation of individual investments; valuation of asset classes and portfolios; developing an investment strategy.

Marks on this module can count towards exemption from the professional examination CA1 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA922 Actuarial Risk Management 2

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	
4	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	McQuire Mr P

Contact Hours

72 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate the ability to apply a wide range of key actuarial concepts in simple traditional and non-traditional situations.
b) Demonstrate knowledge and understanding of complex techniques applicable to solve problems using core actuarial concepts in the context of current professional actuarial practice.
c) Demonstrate a high level of understanding of the main body of knowledge for the module.
d) Demonstrate skill in calculation and manipulation of the material written within the module.
e) Apply a range of concepts and principles of core actuarial concepts in various contexts.
f) Demonstrate skill in solving problems using core actuarial concepts by various appropriate methods.
g) Understanding of the current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate ability for logical argument.
b) Demonstrate ability to work with relatively little guidance.
c) Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
d) Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences.
e) Demonstrate judgemental skills.
f) Demonstrate numeracy and computational skills.
g) Demonstrate time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effect modes of working, and to act autonomously.
h) Demonstrate study skills needed for continuing professional development.
i) Demonstrate decision-making skills in complex situations.
j) Demonstrate the ability to produce written documents; undertake online research; communicate using e-mail.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Students will be provided with the textbook, Understanding Actuarial Management: the actuarial control cycle (second edition), edited by Bellis, Lyon, Klugman & Shepherd, The Institute of Actuaries of Australia and the Society of Actuaries, 2010.

Synopsis *

The aim of this module is to develop the student's ability to apply a wide range of key actuarial concepts in simple traditional and non-traditional situations. Outline syllabus includes: how to do a professional job; contract design; modelling; data; setting assumptions; expenses; pricing and financing strategies; valuing liabilities; accounting and disclosure; surplus and surplus management; sources of risks; risks in benefit schemes; pricing and insurance risks; the risk management process; risk management tools; capital management and monitoring experience.

Marks on this module can count towards exemption from the professional examination CA1 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA923 Introduction to Actuarial Research

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	15 (7.5)	50% Coursework, 50% Project	Kalli Dr M

Contact Hours

21 hours

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:
1. produce technical and scientific documentation and present reports on actuarial analysis using LaTex;
2. demonstrate skills in relevant computing utilities and the statistical package R;
3. select suitable techniques to analyse data, evaluate and develop models, and interpret the results appropriately;
4. demonstrate comprehensive knowledge and understanding of topical research areas in actuarial science which are not covered in detail in taught modules;
5. apply a range of mathematical, statistical and actuarial concepts and techniques in a particular topical area of actuarial research;
8.6. produce a coherent and accurate report on a topical research area of actuarial science which is of a standard comparable to professional documents.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1. plan and implement analysis of unfamiliar material in a professional manner;
2. use relevant computing skills, including use of appropriate document preparation and word-processing packages;
3. demonstrate effective communication skills;
4. demonstrate a capability for independent research and problem solving skills;
5. demonstrate intellectual independence and an ability for independent learning and time management;
6. demonstrate an ability to select material from source texts, either recommended to or found by the student, and show critical awareness of the relationship of the material to background and to more advanced material.

Method of Assessment

50% Project, 50% coursework

Preliminary Reading

(Indicative list, current at time of publication. Reading lists will be published annually)
Porteous, B. and Tapadar, P. (2005). Economic Capital and Financial Risk Management for Financial Services Firms and Conglomerates. Palgrave Macmillan.
Sweeting, P. (2011). Financial Enterprise Risk Management. Cambridge University Press.
Thomas, R.G. (2015) Loss Coverage: Why Insurance Works Better With Some Adverse Selection (To be published)
Cairns, A.J.G., Blake, D., Dowd, K., Coughlan, G.D., Epstein, D., Ong, A., and Balevich, I. (2009) A quantitative comparison of stochastic mortality models using data from England and Wales and the United States. North American Actuarial Journal 13(1): 1-35

Pre-requisites

MA921 and MA953 are co-requisites

Synopsis *

The aim of the module is to introduce the students to actuarial research topics. The students will be introduced to research tools which they will use to carry out a short project on one of these topics. Outline syllabus includes: Scientific word-processing and computing, in which students are introduced to, and gain experience of, the main computing utilities currently used in the School and across campus which are relevant to the course. Scientific word-processing will be taught using LaTex. Students will also be introduced to the statistical software R. Topics in advanced topical actuarial research: Students will be introduced to areas of actuarial research which are topical and are of interest to the actuarial profession. This may include, but is not limited to, advanced topics on financial risk management, mortality models and adverse selection. Project work: There is no fixed syllabus for this component of the course. Students will work on one of the areas of actuarial research introduced in the course. They will produce a review of existing literature on the particular topic to gain a better understanding of the issues involved. The students will then be required to make a contribution to the knowledge and understanding of that particular area of research and produce a written report.

MA930 Investment Analysis and Portfolio Management

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

72 hours of lectures and classes

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the theory.
b. show a comprehensive understanding of the complex techniques applicable to solve problems
c. appreciate recent developments and methodologies in investment analysis and the links between the theory and their practical application and to critically evaluate such methodologies.
d. demonstrate a comprehensive understanding of the complex current issues relevant to the investment market.
e. show an ability to understand, select and apply appropriate methods in portfolio management.

The intended generic learning outcomes. On successful completion of the Module, students will have:
a. developed a logical mathematical approach to solving complex problems.
b. developed skills in written communication to both technical and non-technical audiences.
c. developed skills in the use of relevant information technology.
d. developed skills in time management, working with others, organisation and studying so that tasks can be planned and implemented at a professional level.

Method of Assessment

80% by a three-hour written examination and 20% by coursework

Preliminary Reading

Bodie Z; Kane A & Marcus A.J : “Investments” 8th Edition ,McGraw-Hill
Brown K C & Reilly F K: “Analysis of Investments and Management of Portfolios” 9th Edition, South-Western CENGAGE Learning
Choudhry M: “An Introduction to Bond Markets” Securities and Investment Institute series, Wiley

Fabozzi F: “Fixed Income Analysis” 2nd Edition, CFA Institute Investment Series, Wiley
Hull John C: “ Options, Futures, and other Derivatives” 7th edition Pearson
Sugden D; Gee & Holmes: “Interpreting Company Reports and Accounts”
FT/Prentice Hall

Synopsis *

This is a core module for the MSc in Finance, Investment and Risk. It introduces the fundamental principles of investment analysis and the theory and techniques of portfolio management, and covers the major issues currently of interest to investors.

The syllabus includes the following: Global investment environment, portfolio theory and practice, fixed income securities, security analysis, derivative securities analysis and derivative securities market, evaluation of asset management, applied portfolio management.

MA931 Financial Risk Management

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	
2	Canterbury	Autumn and Spring	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

72 hours of lectures and classes

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate in-depth knowledge and understanding of complex techniques used in risk management in financial institutions.
b) Demonstrate an ability to select and apply a range of risk management techniques in various contexts.
c) Demonstrate knowledge and understanding of complex current issues in Risk Management in the context of current professional practice.
d) Demonstrate a high level of understanding of the main body of knowledge for the module.
e) Apply a range of concepts, principles of Risk Management in various contexts.
f) Understand the current practical applications of the module material.

The intended generic learning outcomes. On successful completion of the module, students will be able to:
a) Argue logically.
b) Work with relatively little guidance.
c) Solve high-level problems, relating to qualitative information, exercise self-direction and originality of thought.
d) Communicate clearly, orally and in writing, to both specialist and non-specialist audiences. Using the appropriate information technology.
e) Exercise sound judgement.
f) Exercise effective time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effective modes of working, and to act autonomously.
g) Exercise study skills needed for continuing professional development.
h) Make decisions in complex situations.

Preliminary Reading

Christoffersen, Peter F., 2012, Elements of Financial Risk Management 2nd Edition, Oxford: Academic Press.
Hull, John C., 2012, Risk Management and Financial Institutions 3rd Edition, Wiley Finance.
Hull, John C., 2010, Options, Futures, and other Derivatives 8th Edition, Pearson/Prentice Hall, and accompanying Student Solutions Manual.

Synopsis *

This is a core module for the MSc in Finance, Investment and Risk. The module's focus is on managing financial risk. It initially introduces the concepts of Enterprise Risk Management as well as risk assessment and strategies in an organisation. The modules will concentrate on the fundamental concepts and issues in identifying, measuring and controlling risk in a financial setting and the tools and techniques to measure and manage financial risk.

Syllabus: ERM concept and risk frameworks in regulatory environments, role of credit agencies; ERM process; financial services industry and risk of financial intermediation; risk categories and classification; risk management tools and techniques; measuring risk; managing risk.

MA933 Contemporary Fund Management

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
4	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

36 hours of lectures and classes

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module, students will be able to:
a) Demonstrate in-depth knowledge and understanding of key steps in the investment management process from the client take-on through to performance evaluation.
b) Make appropriate asset allocation decision, and evaluate performance.
c) Demonstrate knowledge and understanding of complex current issues in Fund Management in the context of current professional practice.
d) Apply appropriate models in asset allocation and security selection.
e) Understand the key operational risk factors and steps that fund managers can take to manage and control the risks.

The intended generic learning outcome. n successful completion of the module, students will be able to:
a) Argue logically.
b) Work with relatively little guidance.
c) Solve high-level problems, relating to qualitative information, exercise self-direction and originality of thought.
d) Communicate clearly, orally and in writing, to specialist and non-specialist audiences. Using the appropriate information technology.
e) Exercise sound judgement.
f) Exercise effective time-management and organisational skills, as evidenced by the ability to plan and implement efficient and effective modes of working, and to act autonomously.
g) Exercise study skills needed for continuing professional development.
h) Make decisions in complex situations.

Method of Assessment

Assessment: 80% by a three-hour written examination and 20% by coursework

Preliminary Reading

The reading material for this course is constantly updated and will be provided by the lecturer during the course.

Synopsis *

This module introduces and further elaborates on the key steps in the investment management process from the client take-on through to performance evaluation, and considers complex current issues in Fund Management in the context of current professional practice.

The syllabus includes:
The security markets, risk, investment management processes, asset allocation, Multi-factor models, Behavioural finance, Hedge funds, Performance measurement, analysis of fund reports.

MA934 Probability and Statistics for Finance

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	I	15 (7.5)	75% Exam, 25% Coursework	
3	Canterbury	Autumn	I	15 (7.5)	75% Exam, 25% Coursework	

Department Checked

75% Examination, 25% Coursework

Progression

48 lectures

Restrictions

The aim of this module is to introduce students to the theory of probability and statistical techniques used in finance. The module provides an understanding of the main areas of the subject that are used in financial applications.

The syllabus includes multivariate variables and distributions, marginal and conditional distributions, independance, covariance, correlation, probability theory, discrete and continuous probability distributions, joint probability distributions, conditional probability and Bayes' Rule, point estimation, hypothesis tsting, interval estimation, simple and multiple regression, applications of statistical theory and methods to Finance.

Synopsis *

This module is designed for students on the MSc in Finance, Investment and Risk. Its objective is to introduce probabilistic and statistical basis to allow analysis of financial data and risk measures. The module is organised in three parts where, from the first to the third one, inferential concepts are developed. The first is an overall introduction to basic probability concepts, including univariate and multivariate probability distributions, summarising indexes and risk measures, such as Value at Risk and Expected Tail Loss. The first part constitutes the foundations on which the inferential topics of the second part lie upon. These consists in parameter estimation and test of hypothesis. In the third and last part we examine the fundamental statistical modelling tool of linear regression. By both considering simple and multiple linear regression model, parameter estimation, prediction and model fitting techniques are discussed.

MA935 Mathematics of Finance

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	

Contact Hours

36 hours of lectures and example classes.

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the module students will be able to:
a. show a systematic knowledge, understanding and critical awareness of the financial theory;
b. to show a comprehensive understanding of the complex techniques applicable to solve problems;
c. to appreciate recent developments and methodologies in financial mathematics and the links between the theory of financial mathematics and their practical application and to critically evaluate such methodologies.

The intended generic learning outcomes. On successful completion of the Module, students will have:
a. developed a logical mathematical approach to solving complex problems
b. developed skills in written communication to both technical and non-technical audiences
c. developed skills in the use of relevant information technology
d. developed skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Preliminary Reading

Adams, A., Booth, P., Bowie, D., & Freeth, A. (2003). Investment Mathematics, John Wiley & Sons.

Cvitani'c, J., & Zapatero, F. (2004). Introduction to the Economics and Mathematics of Financial Markets. Massachusetts Institute of Technology.

Wilmott, P. (2006). Paul Wilmott on Quantitative Finance. John Wiley & Sons

Synopsis *

The module covers mathematical techniques used in general areas of finance as well as in investment. Its focus is on the application of such techniques and mathematical models to quantitative finance.
The syllabus includes interest rates, time value of money, annuities, investment valuation, fixed income instruments, stochastic models for investment returns, modern portfolio theory and asset pricing, optimal consumption/portfolio strategies, and bond analysis.

MA936 Financial Modelling and Analysis

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	100% Coursework	

Contact Hours

36 hours (8 hours of lectures and 28 hours of computer classes)

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the Module, students will be able to:
a) Develop a better understanding of the principles of specific financial, mathematical and statistical techniques introduced in other modules or covered in lectures.
b) analyse, summarise and prepare financial data.
c) develop financial computer models to solve a range of financial problems.
d) apply, interpret and communicate the results of the models derived in c).

The intended generic learning outcomes. On successful completion of the Module, students will have developed a logical mathematical approach to solving problems. They will have developed skills in oral and written communication using appropriate information technology and working in groups.

Preliminary Reading

The module is practical and its focus is on implementation of the theoretical models learnt throughout the programme using Excel. There is no set reading for the module, and the lecturer will provide the necessary course material.

Synopsis *

This modules has been designed in response to the industry's need for practitioners to be able to provide appropriate documentation including an audit trail and a summary of the modelling work undertaken.
The modules provides practice on a range of spreadsheet models used in finance, analysis of the results and scenario testing as well as documentation of the modelling work as practiced in industry.

MA937 Communications in Finance and Investment Writing

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	15 (7.5)	60% Exam, 40% Coursework	

Contact Hours

36 (12 hours of lectures, 24 hours of discussion classes and practice classes)

Learning Outcomes

The intended subject specific learning outcomes.
Draft communications relating to financial technical material intended to be read by a person with little expert knowledge of finance, or a person with financial technical knowledge, to a standard where the drafts would:
-be acceptable as final documents without major changes or rewriting, though a moderate number of more minor changes might still be required,
-be to a standard which might be appropriate for a trainee in finance, rather than a specialist experienced financier,
-convey the most important points clearly and contain no major mis-statements of fact or omissions or unsupported opinion,
-if appropriate, perform simple calculations to present a summary of the quantitative information and an analysis of the given information
Perform oral presentations that would:
-be to a standard which might be appropriate for a trainee in finance, rather than a specialist experienced financier,
-convey the most important points clearly,
-be tailored towards the assumed knowledge of the audience,
-is supported by appropriate visual aids,

The intended generic learning outcomes. On successful completion of the Module, students will have developed skills in the manipulation of financial material and will have shown an ability for logical argument. They will have developed skills in organising information clearly, responding to written sources, presenting information orally and adapting appropriate styles for different audiences; understanding the limits and potentialities of arguments based on quantitative information; using judgmental skills and working in groups.

Preliminary Reading

This is primarily a practical module. The majority of the reading will be provided by specific lecture notes.

Synopsis *

Effective communication in writing or in a presentation is as important in industry as are technical skills, whether in corporate and individual client facing roles, trading, publishing investment reports and providing summary report for the board. The module provides guidelines for good communication and practice in a variety of situations and to a variety of audiences. Students will learn to analyse, summarise, or present published reports or short and long reports that they themselves generate based on their knowledge in other finance subjects taught in the programme. The module will thus complete the students' skill set in the area of finance.

MA938 Fixed Income Analysis

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

36 hours of lectures.

Preliminary Reading

Main textbook:
Fabozzi, F.J. (2007). Fixed Income Analysis. Second Edition. Wiley. New Jersey.
Other recommended textbooks:
Tuckman B. (2002) Fixed Income Securities: Tools for Today's Markets, Second Edition, University Edition
Thau A. (2010) The Bond Book, Third Edition: Everything Investors Need to Know About Treasuries, Municipals, GNMAs, Corporates, Zeros, Bond Funds, Money Market Funds, and More. Third Edition. McGraw-Hill.

Pre-requisites

None

Synopsis *

In this module, valuation of fixed income or debt securities, and the risk involved in investing in these securities is presented and analysed. The course starts with simple bond and builds up to more complicated fixed income securities such as mortgage-backed and asset-backed securities often traded in the market. Throughout the module the theoretical concepts are combined with the application of the theory using extensive examples. Students will apply their knowledge of the theory using relevant software.

The syllabus includes the following: Different types of bonds and features of debt securities, Risk associated with investing in bonds, Overview of bond sectors and instruments, valuation of Bonds, Yield measures, Spot rates and Forward rates, Interest Rate Risk – The duration model – Convexity, Term structures and volatility of interest rates, Valuing bonds with embedded options
Mortgage-backed sector of the bond market, Asset-backed sector of the bond market, Valuing mortgage-backed and asset-backed securities.

MA939 Case Studies in Finance

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	100% Coursework	

Contact Hours

5 hours of lectures, contact hours to be arranged with supervisor.

Learning Outcomes

The intended subject specific learning outcomes. Depending on the case study selected by the student, on successful completion of the module students will have
a. enhanced their knowledge and understanding of the theories in finance and risk, and the techniques used to analyse and solve problems in major areas of finance and risk.
b. gained the ability to apply the theoretical concepts in mathematics, statistics and finance to real life cases in finance and risk.
c. enhanced their ability to apply a range of mathematical, statistical and financial and techniques to real life cases related to finance and risk.
d. gained a deep understanding of the market/environment relevant to the particular case and the issues of interest/concern.
e. gained the ability to select and use a range of financial modelling and computing techniques in the context of the case study.
f. gained the skills to search for and select material relevant to and required for the case study.
g. improved their ability to write a case report of a standard comparable to professional documents.

The intended generic learning outcomes. On successful completion of the module, students will have
a. improved their communication skills.
b. gained the ability to interpret quantitative information.
c. improved their computing skills.
d. enhanced the ability for independent research and problem solving skills.

Pre-requisites

None

Synopsis *

There is no specific syllabus for this course. Students select from a range of case studies covering a variety of financial topics. The theoretical background for the case studies is covered in the MSc finance specialist subjects in the first two terms. Students use their knowledge of the theory and techniques of finance, to analyse and report on the selected cases. The emphasis is on application of the financial techniques using real life data, producing results and analysis and interpretation of the results for particular cases.
Students are introduced to the methodology to carry out case studies and learn how to write case study reports in the lectures.

MA950 Prophet

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	100% Coursework	
2	Canterbury	Autumn	M	15 (7.5)	100% Coursework	Srinivasan Ms V

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the Module, students will be able to:
a) demonstrate skills in specific actuarial software and information technology (e.g. PROPHET)
b) understand the principles of specific actuarial mathematics techniques

The intended generic learning outcomes. On successful completion of the Module, students will have eveloped skills in solving actuarial problems using appropriate computer techniques. They will also have developed skills using appropriate information technology.

Method of Assessment

100% coursework

Synopsis *

This module gives students practical experience of working with the financial actuarial model, PROPHET, which is used by commercial companies worldwide primarily for profit testing, valuation and model office work. On successful completion of the module, students will have developed skills in solving actuarial problems using appropriate computer techniques. They will also have developed skills using appropriate information technology. Outline syllabus includes: overview of the uses and applications of PROPHET; introduction on how to use the software package (including security implications); using Example Model Office to perform and check the results (for reasonableness) on new business profit tests on various products using the edit facility on the model point file, parameter file and global file; creation of a new product on PROPHET using an empty workspace and selecting the appropriate indicators and variables for that product; setting up a model point file, parameter file and global file for the new product and also setting up a run setting and run structure for this product; performing a profit test for the new product using one in force model point and one new business model point and checking the cash flow results obtained; performing a number of sensitivity tests on a series of new business model points to achieve a given profit criteria; reporting on dependencies in Diagram View; updating the library and product; using the re-scan and regeneration of products facilities.

MA951 Prophet 2

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	100% Coursework	Srinivasan Ms V

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes.
On successful completion of the Module, students will be able to:
a) demonstrate further skills in specific actuarial software and information technology (e.g. PROPHET)
b) further understand principles of specific actuarial mathematics techniques

The intended generic learning outcomes.
On successful completion of the Module, students will have developed skills in solving actuarial problems using appropriate computer techniques. They will also have developed skills using appropriate information technology.

Method of Assessment

100% coursework

Pre-requisites

MA950 PROPHET 1

Synopsis *

This module builds on the knowledge of the use of PROPHET introduced to students in MA950 – PROPHET 1. On successful completion of the Module, students will have developed skills in solving actuarial problems using appropriate computer techniques. They will also have developed skills using appropriate information technology. Outline syllabus includes: using Example Model Office to perform and check the results (for reasonableness) on Model Office runs using multiple products and the total business summary file including when changes have been made to the assumptions to the global file; using the Model Office run view to analyse the effect that changes to the input data has had on the model; running Model Office with products from the Example Model Office and creating reports on model office runs summarising the results obtained; using PROPHET "goal seek" capability to find a premium rate that achieves a desired level of profitability for a new business model point; using PROPHET "goal seek" capability to find a premium rate that achieves a desired level of profitability for a new business model point using 3 further measures of profitability (Internal Rate of Return, Break Even Month and Profit Margin); using the PROPHET Data Conversion System to read an input file in ASCII format to i) perform a number of calculations on the individual policy data and then produce output files for use by PROPHET system, ii) add validation checks and correction rules to the programme and iii) group the data so that grouped model point file rather than individual model point file data is produced; calculating valuation reserves for a number of policies on several valuation bases for a Term Assurance product and checking the results using a spreadsheet.

MA952 Financial Modelling

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	15 (7.5)	100% Coursework	James Mr A

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the Module, students will be able to:
a) understand the principles of specific actuarial mathematics techniques
b) analyse, summarise and prepare raw data
c) develop simple actuarial computer models to solve actuarial problems
d) apply, interpret and communicate the results of the models derived in c).

The intended generic learning outcomes. On successful completion of the Module, students will have developed a logical mathematical approach to solving problems. They will have developed skills in oral and written communication using appropriate information technology and working in groups.

Method of Assessment

100% coursework

Synopsis *

This module introduces computer-based financial models in Microsoft Excel and shows how to analyse and summarise data, develop and document a model, and to apply, interpret and communicate the results. On successful completion of the module, students will be able to (a) understand the principles of specific applied actuarial techniques, (b) prepare, summarise and analyse raw data, (c) develop and document computer models to solve actuarial problems, and (d) apply, interpret and communicate the results of the models.

MA953 Communications

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	15 (7.5)	50% Coursework, 50% Exam	
1	Canterbury	Autumn and Spring	M	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Autumn and Spring	M	15 (7.5)	50% Coursework, 50% Exam	Rogers Mr I

Contact Hours

36 hours

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of the Module, students will be able to:
-Draft communications relating to actuarial technical material intended to be read by a non-actuarial person, or a specified technical actuarial person, to a standard where the drafts would
-be acceptable as final documents without major changes or rewriting, though a moderate number of more minor changes might still be required
-be to a standard which might be appropriate for a newly qualified actuary, rather than a specialist experienced actuary
-convey the most important points clearly and contain no major mis-statements of fact or omissions or unsupported opinion
-Create and perform oral presentations that would
-be to a standard which might be appropriate for a newly qualified actuary, rather than a specialist experienced actuary
-convey the most important points clearly
-be tailored towards the assumed knowledge of the audience

The intended generic learning outcomes. On successful completion of the Module, students will have developed skills in the manipulation of actuarial material and will have shown an ability for logical argument. They will have developed skills in organising information clearly, responding to written sources, presenting information orally and adapting style for different audiences; understanding the limits and potentialities of arguments based on quantitative information; using judgmental skills and working in groups.

Method of Assessment

50% Examination, 50% Coursework

Preliminary Reading

There is no formal preliminary reading list. However, since this module requires a good standard of spoken and written English at the start of the course, students will be expected to undertake whatever private study is required to reach this standard, in advance of the course starting.

Synopsis *

Actuaries deal with complex actuarial and financial concepts in multi-disciplinary teams, so it is vital that they can communicate these concepts clearly and effectively to a wider audience. This module helps students to develop the ability to present fundamental actuarial ideas and concepts clearly to a wide range of different recipients. Students will be expected to demonstrate effective communication skills using a variety of different media, including PowerPoint slide presentations, and formal/informal letters and e-mails. Exercises are based on real-world commercial situations, and there are two group exercises, one of which is assessed.

Marks on this module can count towards exemption from the professional examination CA3 of the Institute and Faculty of Actuaries. Please see http://www.kent.ac.uk/casri/Accreditation/index.html for further details.

MA960 Dissertation

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	60 (30)	100% Project	Waterstraat Dr N

Contact Hours

10 hours of supervision

Learning Outcomes

On successful completion of this module, students
a. will be aware of the depth and wider relevance of an advanced mathematical topic of current interest,
b. will have developed an ability to consider detailed, rigorous mathematical argument, whether within the context of an established mathematical theory or a substantive application of a mathematical theory,
c. will have developed their ability to express logical, coherent mathematical thought in an extended piece of work,
d. will have improved their technical writing and oral communication skills gained in the Mathematical Inquiry and Communication module, as well as consolidated their skills in problem solving, logical argument, and geometric, algebraic and analytic thinking.

Method of Assessment

100% project

Preliminary Reading

Texts depend on the individual dissertation topics.

Pre-requisites

Students must pass the module MA961 (Mathematical Inquiry and Communication) to progress to the Dissertation. However students are required to start planning for the Dissertation during the Spring term

Synopsis *

The dissertation represents the culmination of the students work in the programme. It offers the students the opportunity to carry out a piece of extended independent scholarship, and to show their ability to organise and present their ideas in a coherent and convincing fashion. Students will be expected to discuss possible dissertation topics with academic staff members of the Mathematics group within SMSAS in the spring term. An initial supervision will be arranged in the Spring term during which the student and supervisor will discuss the approaches to the topic and draw up a timetable plan which will include some meetings to discuss progress and areas of difficulty. The supervisor will comment on a draft before submission. The topic of the dissertation will depend on the mutual interests of the student and the student's chosen supervisor.

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor

Contact Hours

15

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of this module, students
(a) will have gained insight and experience into creative mathematical processes.
(b) will have enhanced professionalism in conducting a short independent study, not only in terms of the quality of the results but also in terms of project management and presentation of results.
(c) will have increased knowledge, understanding, intuition and computational expertise in a specific mathematical application, interpreted broadly to include mathematical thought in a range of contexts, chosen from an annual list of topics.

On completion of the module students will have:
(i) an ability to investigate an application of mathematics in depth, in the context of an open-ended investigation,
(ii) an enhanced ability to write a coherent technical report,
(iii) an ability to design a poster (interpreted broadly to include a web page or web-based animation),
(iv) an ability to use mathematical typesetting software (LATEX) to professional level,
(v) an ability to explain complex arguments to a scientifically literate, but non-specialist audience.

Method of Assessment

50% Coursework, 50% Project

Preliminary Reading

For the project: Texts depend on the topics offered.
For the Key Skills:
K Hanston, How to think like a mathematician. (Cambridge University Press, 2009)
NJ Higham, Handbook of writing for the mathematical sciences. (SIAM, 1998)
SG Krantz, A primer of mathematical writing. (American Mathematical Society, 1997)
F Mittelbach et al, The LaTeX companion. (Addison-Wesley, 2004)

Synopsis *

The module consists of key skills classes and project work. The project will be a substantial investigation of a problem arising from one of the optional modules. The topic of the dissertation will depend on the mutual interests of the student and the student's chosen supervisor. There will be workshops on key skills relevant to mathematical writing and communication. The coursework will be set in these workshops and will include a presentation.

MA962 Geometric Integration

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	15 (7.5)	70% Exam, 15% Coursework, 15% Project	Krusch Dr S

Contact Hours

30 hours

Learning Outcomes

On successful completion of this module students will have increased their knowledge, understanding, intuition and computational expertise in:

(i) numerical methods and their properties;
(ii) geometric interpretation of differential equations and numerical algorithms;
(iii) the meaning and interpretation of error in approximations, in particular the relative importance of local errors versus global properties;
(iv) the importance, meaning and interpretation of numerical stability;
(v) specific sophisticated numerical tools which preserve certain mathematical structures;
(vi) proficient use of mathematical software such as MatLab to masters level.

We expect students successfully completing the module to have:

(i) an enhanced ability to reason and deduce confidently from given definitions and constructions;
(ii) an enhanced understanding of what is meant by an answer to a modelling problem;
(iii) an enhanced ability to read independently and manage their time;
(iv) enhanced skills with mathematical and graphical software, to postgraduate level.

On completion of the module students will have:

(v) matured in their problem formulating and solving skills;
(vi) consolidated a wide variety of Calculus, Linear Algebra, Mathematical Modelling, and Mathematical Methods based skills.

Method of Assessment

70% Examination, 15% Coursework, 15% Project

Preliminary Reading

All texts are available in the Templeman library and are recommended for background reading.
Books:
Simulating Hamiltonian Dynamics, Leimkuhler and Reich, Cambridge University Press, 2005.
Geometric Numerical Integration, Hairer and Lubich and Wanner, second edition, Springer Verlag, 2006.
Review articles:
Six Lectures in Geometric Integration, MacLachlan and Quispel, in Foundations of Computational Mathematics pages 155-210, ed. R. DeVore, A. Iserles, E. S¨uli, Cambridge University
Press, Cambridge, 2001. (Available online)
Geometric Integration and its Applications, Handbook of Numerical Analysis, Volume XI NorthHolland 2000.

Pre-requisites

MA587 is highly recommended as a pre-requisite. Otherwise MA587 is a co-requisite.

Synopsis *

The equations studied in this module will be ordinary differential systems, especially Hamiltonian systems. The aim of this subject area is to obtain and study numerical solutions of these systems that preserve specific qualitative and geometric properties. For certain differential equations, these geometric methods can be far superior to standard numerical methods. The syllabus includes: A review of basic numerical methods, variational methods and Hamiltonian mechanics; Properties that numerical methods can preserve (first integrals, symplecticity, time reversibility); Geometric numerical methods (modified Euler and Runge-Kutta methods, splitting methods); Use and misuse of the various notions of error.

MA963 Poisson Algebras and Combinatorics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

up to 30 hours

Learning Outcomes

The intended subject specific learning outcomes. Students who successfully complete this module will
(a) have a sound knowledge of the basic structure of Poisson algebras and their quantisations and be familiar with examples including quantum affine spaces and quantum matrices;
(b) be able to compute symplectic leaves of Poisson algebras;
(c) have increased their knowledge of the theory of symmetric groups;
(d) have increased their knowledge of the theory and practice of matrices and linear algebra;
(e) have learned how to formulate and prove statements about Poisson algebras in precise abstract algebraic language;
(f) have a sound knowledge of combinatorial objects such as Cauchon diagrams, pipe dreams, planar networks.

The intended generic learning outcomes. On completion of the module students will
(a) have matured in their problem formulating and solving skills;
(b) have an enhanced capacity to communicate mathematical statements and conclusions;
(c) better be able to appreciate mathematics as a unified discipline;
(d) consolidated a wide variety of Calculus, Linear Algebra, Geometry, Combinatorics, and Mathematical Methods based skills;
(e) appreciate the power of algorithmic methods in Algebra/Combinatorics/Geometry.

Method of Assessment

80% examination and 20% coursework.

Preliminary Reading

We will not follow a single text, and the lecture notes will cover the entire syllabus. Nevertheless the following books contain a large amount of the material.
KA Brown & KR Goodearl, Lectures on Algebraic Qantum Groups. (Advanced Courses in Mathematics. CRM Barcelona, Birkhäuser Verlag, Basel, 2002) (B)

FR Gantmacher, The theory of matrices. Vol. 1. (AMS Chelsea Publishing, Providence, RI, 1998) (B)
S Launois & TH Lenagan, From quantum algebras to total non-negativity. (available at www.kent.ac.uk/ims/personal/sl261/Teaching/LTCC2009/LTCC2009.pdf) (R)

P Vanhaecke, Integrable Systems in the realm of Algebraic Geometry. (Lecture Notes in Mathematics 1638, Springer-Verlag, 2001) (B)

Pre-requisites

None

Synopsis *

The general topics of this module are Poisson algebras, their quantisations, and applications to combinatorics. Poisson algebras first appeared in the work of Siméon-Denis Poisson two centuries ago when he was studying the three-body problem in celestial mechanics. Since then, Poisson algebras have been shown to be connected to many areas of mathematics and physics.

This module will provide a rigorous but example led introduction to the main ideas and notions of Poisson algebras and their quantisations. Specific applications will be to problems in combinatorics and to the study of totally positive matrices that are used in statistics, game theory, mathematical economics, mathematical biology.... This module will have a strong computational strand: a large part of the module will be devoted to explicit computations of symplectic leaves of Poisson algebras and to algorithmic methods in total positivity.

The syllabus will be
• Poisson algebras: basic structure and examples. Symplectic leaves;
• Symplectic leaves in Poisson matrix varieties and Bruhat order on the symmetric group;
• Deformation of Poisson algebras: an introduction to algebraic quantum groups and their prime ideals through examples (quantum plane, quantum matrices...);
• Totally positive/nonnegative matrices: definition, examples, properties and cell decomposition.
• Link between total positivity and Poisson algebras;
• Algorithmic methods for detection of totally nonnegative matrices.

The curriculum can be extended in various ways: Poisson-Lie groups, Coxeter groups, Hopf algebras, representation theory, and these are suitable for project work.

MA964 Applied Algebraic Topology

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	70% Exam, 15% Coursework, 15% Project	Shank Dr RJ

Contact Hours

24-36

Learning Outcomes

The Intended Subject Specific Learning Outcomes. Students who have successfully completed this module will:
(a) understand the basic concepts of topology with particular emphasis on cw complexes, manifolds and simplicial complexes;
(b) be able to apply topological methods to real-world problems;
(c) be able to use homological and computational methods to solve topological problems;
(d) have an improved geometric and algebraic intuition;
(e) have an enhanced ability to formulate and prove abstract mathematical statements, and appreciate their connection with concrete calculation;
(f) have enhanced their computational skills.

The Intended Generic Learning Outcomes. We expect students successfully completing the module to have:
(a) an enhanced ability to communicate their own ideas clearly and coherently;
(b) an enhanced ability to read and comprehend mathematical ideas;
(c) matured in their problem solving skills;
(d) a greater appreciation of abstract concepts;
(e) consolidated their grasp of a wide variety of mathematical techniques and methods.

Method of Assessment

70% Examination, 15% Coursework, 15% Project

Preliminary Reading

MA Armstrong, Basic Topology. (Springer, 1983) (E)
Kaczynski, Mischaikow & Mrozek, Computational Homology. (Springer, 2004) (R)
Ghrist, Bar codes: The persistent topology of data. (Bulletin of the AMS, vol 45, no 1 (2008) 61–75) (B)
WS Massey, A Basic Course in Algebraic Topology. (Springer, 1991) (R)
de Silva & Ghrist, Homological Sensor Networks. (Notices of the AMS, vol 54, no 1, 2007 10–17) (B)
WA Sutherland, Introduction to Metric & Topological Spaces. (2nd edition, Oxford UP, 2009) (R)

Pre-requisites

MA567 Topology

Synopsis *

There is growing interest in applying the methods of algebraic topology to data analysis, sensor networks, robotics, etc. The module will develop the necessary elements of algebra and topology, and investigate how these techniques are used in various applications. The syllabus will include: an introduction to manifolds, CW complexes and simplicial complexes; an investigation of the elements of homotopy theory; an exploration of homological and computational methods; applications such as homological sensor networks and topological data analysis.

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor

Contact Hours

42-48 hours

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of this module students will have increased their knowledge, understanding, intuition and computational expertise in:
(a) rigorous thinking
(b) detecting symmetries and common patterns
(c) systematic observation, generalization and techniques of proof
(d) using group theory to calculate with symmetries
(e) distinction and classification of objects up to equivalences and symmetries
(f) the use of \normal forms" and \invariants" to distinguish symmetry classes
(g) combinatorial analysis and enumeration of symmetry classes and group orbits
(h) proficient use of mathematical software such as Maple and MAGMA to masters level

The Intended Generic Learning Outcomes. We expect students successfully completing the module to have
(i) an enhanced ability to correctly formulate classification problems and solve them efficiently;
(ii) enhanced skills in understanding and communicating mathematical results and conclusions;
(iii) a holistic view of mathematics as a problem solving and intellectually stimulating discipline;
(iv) an appreciation of algorithms and computational methods in algebra and group theory.

On completion of the module students will have:
_ matured in their problem formulating and solving skills;
_ consolidated a variety of tools from abstract algebra to model and classify concrete objects and configurations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

G Burde & H Zieschang, Knots. (De Gruyter Studies in Mathematics, 1985, Walter de Gruyter, ISBN 3-11-008675-1)

LH Kauffman, On Knots. (Princeton, 1987, ISBN 0-691-08435-1)
A Kerber, Applied finite group actions. (Springer, 1999, ISBN/ISSN 3540659412)
WBR Lickorish, An introduction to knot theory. (Springer, 1997, ISBN/ISSN 038798254X)
V Manturov, Knot Theory. (Chapman & Hall, 2004, ISBN 1-415-31001-6)
K Murasugi, Knot theory and its applications. (Birkhäuser, 1996, ISBN/ISSN 0817638172)

Pre-requisites

MA565

Synopsis *

In this module we will study certain configurations with symmetries as they arise in real world applications. Examples include knots described by "admissible diagrams" or chemical structures described by "colouring patterns". Different diagrams and patterns can describe essentially the same structure, so the problem of classification up to equivalence arises. This will be solved by attaching "invariants" which are then put in "normal form" to distinguish them. The syllabus will be as follows: (a) Review of basic methods from linear algebra, group theory and discrete mathematics; (b) Permutation groups, transitivity, primitivity, Burnside formula; (c) Finitely generated Abelian groups; (d) Applications to knot theory, Reidemeister moves, the Abelian knot group; (e) Examples, observations, generalizations and proofs; (f) General Polya-enumeration (as an extension of the Burnside formula).

MA967 Quantum Mechanics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
3	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	Dunning Dr C

Contact Hours

40-42

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the level 7 module students will be able to:
1, demonstrate systematic understanding of introductory quantum theory
2. demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: potential wells and barriers in one dimension, the treatment of eigenvalue problems in quantum mechanics and the hydrogen atom.
3. apply a range of concepts and principles in quantum mechanics in loosely defined contexts, showing good judgement in the selection and application of tools and techniques.

The intended generic learning outcomes.
On successfully completing the level 7 module students will be able to:
1. work competently and independently, be aware of their own strengths and understand when help is needed
2. demonstrate a high level of capability in developing and evaluating logical arguments
3. communicate arguments confidently with the effective and accurate conveyance of conclusions
4. manage their time and use their organisational skills to plan and implement efficient and effective modes of working
5. solve problems relating to qualitative and quantitative information
6. communicate technical material effectively
7. demonstrate an increased level of skill in numeracy and computation
8. demonstrate the acquisition of the study skills needed for continuing professional development.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

FW Byron, Mathematics of classical and quantum physics. (Addison-Wesley, 1970) (B)
A Durrant, Quantum Physics of Matter. (Institute of Physics 2000) (B)
J Manners, Quantum Physics: An introduction. (Institute of Physics, 2000) (B)
MA Nielsen & IL Chuang, Quantum Computation and Quantum Information. (Cambridge University Press, 2001) (B)

AIM Rae, Quantum Physics: A Beginner's Guide. (Oneworld Publications, 2005) (B)
JJ Sakurai, Modern quantum mechanics. (Addison-Wesley, 1994) (B)
R Shankar, Principles of quantum mechanics. (Plenum Press, 1994) (B)
K Hannabuss, An introduction to quantum theory. (Oxford University Press, 1997) (B)

Pre-requisites

None.

Synopsis *

Quantum mechanics provides an accurate description of nature on a subatomic scale, where the standard rules of classical mechanics fail. It is an essential component of modern technology and has a wide range of fascinating applications. This module introduces some of the key concepts of quantum mechanics from a mathematical point of view. Outline syllabus: why classical mechanics fails; the Schrödinger equation and interpretation of the wavefunction; applications of quantum mechanics.

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor

Contact Hours

24-36

Learning Outcomes

Learning Outcomes
On successful completion of the module, students will have an understanding of two significant and substantial areas of applied mathematics, namely the wave equation and digital processing, together with their applications to acoustics and to music recording.
Students who have successfully completed this module will:
· Understand a range of basic concepts used to model and process sound waves and digital signals · Have a reasonable ability to perform basic computational skills:
calculations with Bessel functions, Discrete Fourier transforms, convolutions, sampling, and filtering · Have a reasonable knowledge, and understand the place in the theory:
solution methods of the wave equation in square and circular domains, properties of Bessel functions and their role in the Fourier series of modulated sin waves, discrete analogues of the Fourier transform and convolution · Be exposed to more advanced material such the Gabor transform which allows musical signals to be analysed mathematically, as well as the rich variety of other methods used to analyse music, such as the geometry of musical rhythms and chord spaces · Gain experience and solve problems using the analytic skills developed, within the application to sound, and understand their relevance to modelling, and digital processing of music · Be aware of, and have the opportunity to perform: relevant computer calculations and graphics such as animations of vibrating drums; sampled, filtered and modulated signals; and spectrograms.

Method of Assessment

70% Examination, 15% Coursework, 15% Project

Preliminary Reading

D. Benson, Music: A Mathematical Offering, Cambridge University Press, 2006 G. Loy, Musimathics: The Mathematical Foundations of Music MIT Press, 2007 S.W. Smith, Digital Signal Processing, Newnes, 2003.
N Collins, Introduction to Computer Music. (Wiley, 2010) (B)
D. Tymoczko, A Geometry of Music Oxford University Press, 2011.
G. Toussaint, The Geometry of Musical Rhythm CRC Press, 2013.
Papers:
GW Don, KK Muir, GB Volk and JS Walker, Music: Broken Symmetry, Geometry and Complexity, Notices of the American Mathematics Society 57 (1) pp 30--49

Pre-requisites

None

Synopsis *

This module is divided into two - one part is about the mathematics of sound both acoustic and digital, and the other is about the structure of music as it affects musical composition. The mathematics of sound includes the study of the linear wave equation, in particular, the mathematics of drums and Chladni patterns. We then move on the mathematics of digital sound - the discrete Fourier transform, the short time Fourier transform and the Gabor transform. Here we can answer questions like, does Louis Armstrong play the trumpet the same way he sings? And, how to slow down music without losing pitch? The mathematics of rhythm and harmony are two very different fields of study. Many world music rhythms can be studied using the Euclidean algorithm, and we will also take a look at the theory of rhythmic tilings which underpin cannons and more modern compositions. Finally, the harmonic progression of a musical composition can be modelled as a path in chord space. In this part of the module, we will look at how simple geometric ideas are used to model voice leading and harmony. For this last part, familiarity with the keyboard would be helpful but is not a pre-requisite.

MA969 Applied Differential Geometry

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

42-48 hours.

Learning Outcomes

The Intended Subject Specific Learning Outcomes. On successful completion of this module students will:
(i) understand basic geometric objects such as curves and surfaces and be able to determine their intrinsic properties
(ii) be able to derive the geometric evolution equations for curves and surfaces and understand the connection with nonlinear integrable systems
(iii) have broadened their experience with the basic concepts in Riemannian geometry such as metrics, connections and curvatures
(iv) have developed awareness of modern applications to mathematical physics, computer vision and image processing

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

R Hartley & A Zisserman, Multiple View geometry in computer vision. (Cambridge university press, 2nd ed, 2003) (B)

R Kimmel, Numerical geometry of images, theory, algorithms and applications. (Springer Verlag, 2003) (B)

PJ Olver, Lectures on moving frames. (preprint, University of Minnesota, 2008) (B)
C Rogers & WK Schief, Bäcklund and Darboux transformations: Geometry and modern applications in soliton theory. (Cambridge University Press, 2002) (B)

IA Taimanov, Lecture on differential geometry. (EMS series of Lectures in Mathematics, 2008) (R)

Pre-requisites

None.

Synopsis *

Differential geometry studies geometrical objects using analytical methods. It originates in classical mechanics. Modern differential geometry has made a huge impact in the development of nonlinear mathematical physics including integrable systems and string theory. Nowadays differential geometry is at the centre of the analysis of pattern recognition, image processing and computer graphics.

Indicative specific subtopics are:
• Theory of curves. Plane and space curves. Euclidean invariants of curves. Frenet frame.
• Theory of surfaces. Metrics on regular surface. Curvature of a curve on a surface. Gaussian curvature and mean curvature. Covariant derivative and geodesics. The Euler-Lagrange equations. Minimal surfaces.
• Evolution of curves and surfaces as integrable systems: Invariant curve evolution. The mean curvature flows. The connection with integrable systems. The modified Korteweg de-Vries equation.
• Curves in Riemannian manifolds: Riemannian metrics, connections, curvatures and geodesics. Curves evolution in Riemannian manifold with constant curvature.
• Modern applications.
i. 2D and 3D projective geometry and application to multiple view geometry in computer vision;
ii. Moving frames, invariant signatures in pattern recognition;
iii. Poisson manifold and Hamiltonian systems.

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor

Contact Hours

42-48 lectures and example classes

Learning Outcomes

The intended subject specific learning outcomes. On successful completion of this module students will:
a) be able to work with fundamental concepts in functional analysis, such as linear operators and functionals;
b) have a grasp of formal definitions and rigorous proofs in analysis;
c) have gained an appreciation of a wider context in which previously encountered concepts from analysis, such as convergence and continuity, can be used;
d) be able to apply abstract ideas to concrete problems in analysis;
e) appreciate differences between analysis in infinite and finite dimensional spaces;
f) be aware of applications of basic techniques and theorems of functional analysis in other areas of mathematics, e.g., approximation theory, and the theory of ordinary differential equations.
In addition M-level students will have
g) an increased ability to understand on their own, and communicate to others, fundamental ideas and results in abstract mathematical analysis

The intended generic learning outcomes. We expect students successfully completing the module to have
a) an enhanced ability to correctly formulate abstract problems and solve them efficiently;
b) enhanced skills in understanding and communicating mathematical results and conclusions;
c) furthered a holistic view of mathematics as a problem solving and intellectually stimulating discipline;
d) an appreciation of the power of abstract reasoning and formal proofs in mathematics and its applications
On successful completion of this module, M-level students will also have:
e) an enhanced ability for independent learning.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Introductory Functional Analysis with Applications, Erwin Kreyszig, John Wiley, 1978.
Principles of Mathematical Analysis. Walter Rudin, International Series in Pure and Applied Mathematics, McGraw-Hill, 1976 3rd edition.
Beginning Functional Analysis, Karen Saxe, Springer, 2002.
Introduction to Functional Analysis, Angus E.Taylor, David C.Lay, John Wiley, 1980 2nd edition.
Functional Analysis. Walter Rudin. McGraw-Hill, 1991 2nd edition.

Pre-requisites

None

Synopsis *

This module will give an introduction to one of the main areas underpinning research in Analysis today: Functional Analysis, which has applications in many sciences, in particular in the modern theory of solutions of partial differential equations. As well as giving the main definitions and theorems in the area, the module will focus on applications, in particular to differential equations and in approximation theory. The following topics will be covered in the module: 1) Linear spaces: Normed and Banach spaces, Inner-product and Hilbert spaces, examples 2) Linear operators and functionals: bounded linear operators, functionals, dual spaces, reflexive spaces, adjoint operators, selfadjoint operators, examples 3) Fundamental theorems: Hahn-Banach, Uniform boundedness principle, Open mapping & Closed graph theorem, Baire Category theorem 4) Fixed point theorems and applications to differential and integral equations 5) Applications in approximation theory: best approximation in Hilbert space, approximation of continuous functions by polynomials. Possible additional topic: Spectral theory of bounded linear operators, weak and weak* topologies, algebras of bounded linear operators.

MA972 Algebraic Curves in Nature

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn and Spring	M	15 (7.5)	70% Exam, 30% Coursework	Hone Prof A

Contact Hours

30 hours

Learning Outcomes

The Intended Subject Specific Learning Outcomes. To increase students' knowledge, understanding, intuition and computational expertise in:
(a) rigorous thinking
(b) calculating with and visualization of geometrical objects
(c) systematic observation, generalization and techniques of proof
(d) the use of geometrical methods in other areas of mathematics and physics
(e) algebraic and analytical techniques for understanding geometry
(f) classification of objects according to their topological and geometrical properties
(g) connecting abstract mathematics to the real world
(h) proficient use of mathematical software such as Maple and MAGMA to masters level

The Intended Generic Learning Outcomes. We expect students successfully completing the module to have
(i) an enhanced ability to correctly formulate geometrical problems and solve them efficiently;
(ii) enhanced skills in understanding and communicating mathematical results and conclusions;
(iii) a holistic view of mathematics as a problem solving and intellectually stimulating discipline;
(iv) an appreciation of algorithms and computational methods in geometry.
On completion of the module students will have:
- matured in their problem formulating and solving skills;
- consolidated a variety of analytical and algebraic tools to model and classify geometrical objects and configurations.

Method of Assessment

70% examination, 30% coursework

Preliminary Reading

JWS Cassels, Lectures on elliptic curves. (LMS Student Texts 24, Cambridge, 1991, ISBN-10 0521425301) (B)

F Kirwan, Complex Algebraic Curves. (LMS Student Texts 23, Cambridge, 1992, ISBN-10 0521423538) (B)
N Koblitz, Algebraic Aspects of Cryptography. (Springer, 1998, ISBN 978-3-540-63446-1) (B)
R Miranda, Algebraic Curves and Riemann Surfaces. (Graduate Studies in Math., vol. 5, AMS, 1995, ISBN 0-8218-0268-2) (B

JH Silverman, The Arithmetic of Elliptic Curves. (Graduate Texts in Mathematics 106, Springer, 1986, ISBN 0-387-96203-4) (B)

ET Whittaker & GN Watson, A Course of Modern Analysis. (Cambridge, fourth edition, 1927 (reprinted 2005), ISBN 0-521-58807-3) (B)

Pre-requisites

None.

Synopsis *

In this module we will study plane algebraic curves and the way that they arise in applications to other parts of mathematics and physics. Examples include the use of elliptic functions to solve problems in mechanics (e.g. the pendulum, or Euler's equations for rigid body motion), spectral curves of separable Hamiltonian systems, and algebraic curves over finite fields that are used in cryptography. The geometrical properties of a curve are not altered by coordinate transformations, so it is important to identify quantities that are invariant under such transformations. For curves, the most basic invariant is the genus, which is most easily understood in terms of the topology of the associated Riemann surface: it counts the number of handles or “holes”. The case of genus zero (corresponding to the Riemann sphere) is well understood, but curves of genus one (also known as elliptic curves) lead to some of the most interesting and difficult problems in modern number theory.

• Review of basic results from complex analysis and topology;
• Riemann surfaces and plane curves in complex affine and projective space;
• The genus of a curve: degree-genus and Riemann-Hurwitz formulae;
• Genus one: elliptic curves and their group structure; elliptic functions and elliptic integrals, with applications;
• Higher genus: functions, divisors and differentials on algebraic curves; Riemann-Roch theorem; example: hyperelliptic curves.

MA973 Basic Differential Algebra

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

28 (if lectured)

Learning Outcomes

The intended subject specific learning outcomes and, as appropriate, their relationship to programme learning outcomes
On successful completion of this module students will:
a) be familiar with basic structures of differential algebra and the ideal/variety correspondence for nonlinear differential systems;
b) be able to simplify and normalize small examples of differential systems and use dedicated computer algebra packages for big ones;
c) be able to separate the generic solution from singular components by way of differential reduction in nonlinear models;
d) be able to write small Maple scripts using the differential algebra functions from the existing Maple library;
e) have strengthened their basic knowledge in commutative algebra and algebraic geometry, viewing also differential objects from an algebraic perspective;
f) have learned how to prove some statements in differential algebra in terms of ideals and reduction;
g) have some knowledge of characteristic sets as an analog of Groebner bases, with skills for computing them manually or by dedicated packages;
h) handle the main tools provided in the Maple package "DifferentialAlgebra" and be able to apply them for various tasks on concrete problems.
The intended generic learning outcomes and, as appropriate, their relationship to programme learning outcomes
On successful completion of the module students will have improved their:
a) skill of specifying problems, solving them algorithmically as much as possible;
b) skill of communicating mathematical statements and conclusions;
c) vision of mathematics as a unified field with powerful analogies;
d) understanding of the complementary nature of analytic / algebraic thinking;
e) appreciation of algorithmic tools for solving mathematical problems;

Method of Assessment

80% examination, 20% coursework

Preliminary Reading

Since the discipline of differential algebra is rather young, there is no suitable textbook on differential algebra, so there will be specific lecture notes for this module, complemented by reading assignments for appropriate passages in the following reference works:

(1) Joseph Fels Ritt, Differential Algebra, Dover Publications, New York, 1966.

(2) Ellis Kolchin, Differential Algebra & Algebraic Groups, Academic Press, NY, 1973.

(3) Andy Magid, Lectures on Differential Galois Theory, 2nd ed., AMS, 1994.

(4) Irving Kaplansky, An Introduction to Differential Algebra, Hermann, Paris, 1957.

(5) Kolchin Seminar in Differential Algebra, http://www.sci.ccny.cuny.edu/~ksda .

The website (5) is a particularly nice starting point for exploring a rich variety of different topics in differential algebra, both elementary and advanced.

Pre-requisites

Polynomials in Several Variables (MA574), or other courses on commutative algebra

Synopsis *

Differential algebra is a relatively recent branch of algebra that exploits the analogies between systems of algebraic equations and nonlinear systems of (mainly ordinary) differential equations. The tools developed in differential algebra are useful for practical problem solving, but they must be used through computer algebra packages since computations can get very heavy. In this module, we will give special emphasis to the package "DifferentialAlgebra" included in the Maple kernel. We will give a rigorous but example led introduction to the main ideas of computer algebra. The main applications to be discussed are the analysis of singularities and the simplification of nonlinear differential systems. As already indicated, the module will have a strong computational flavour: Students will explore concrete examples with the computer algebra system Maple, comparing hand computations with the results achieved by the full-blown algorithms and dispatching large computations to the package. Outline Syllabus: Differential rings and field; differential ideals and homomorphisms; rankings; Ritt's reduction algorithm; characteristic sets; singular solutions.

MA974 Short Dissertation (Mathematics)

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	30 (15)	80% Project, 20% Coursework	

Contact Hours

8

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:

1. will be aware of the width, depth and wider relevance of an advanced mathematical topic of current interest,
2. will have developed an ability to carefully consider detailed, rigorous mathematical argument, whether within the context of an established mathematical theory or a substantive application of a mathematical theory,
3. will have developed their ability to express logical, coherent mathematical thought in an extended piece of work,
4. will have improved their technical writing and oral communication skills gained in the Mathematical Inquiry and Communication module, as well as consolidated their skills in problem solving, logical argument, and geometric, algebraic and analytic thinking.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1. read and understand advanced technical material independently,
2. will have enhanced their ability to plan, implement and complete an extended piece of work to professional level,
3. will have demonstrated initiative in the development of a line of research, argument and exposition,
4. will have demonstrated an ability to formulate detailed rigorous argument,
5. will have communicated in writing the width and depth of their understanding of a substantive body of knowledge,
6. will be able to speak on an advanced topic and answer questions on it and
7. will have developed an ability in basic research methods such as writing a literature survey including appropriate selection of materials and their critical evaluation.

Students successfully completing the module will have acquired and demonstrated a level of intellectual stamina that would enable them to enjoy independent continuing professional development in a mathematical sciences based career.

Method of Assessment

Dissertation (80%) together with a short presentation and viva (20%).

Preliminary Reading

Texts depend on the individual dissertation topics.

Synopsis *

The short dissertation represents the culmination of the student's academic work in the programme. It offers students the opportunity to carry out a piece of extended independent scholarship, and to show their ability to organise and present their ideas in a coherent and convincing fashion.
The topic of the dissertation will depend on the mutual interests of the student and the student's chosen supervisor.

MA975 Short Dissertation (Statistics)

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	30 (15)	95% Project, 5% Coursework	Ridout Prof M

Contact Hours

8

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students:
1. will be aware of the relationship of the material to background material and to more advanced material;
2. will have written a coherent account of an area of Statistics, with particular reference to applications in Finance, as/if appropriate;
3. will have performed statistical analyses that show the depth of student understanding of the statistical methods relevant to the topic. This is especially the case for students of Statistics; students of Statistics in Finance may alternatively have demonstrated understanding of the importance of Statistics to Finance. For the last two degrees, these issues will depend on the topic studied;
4. will have presented analyses and drawn conclusions with clarity and accuracy;
5. will have understood theoretical and practical aspects of analysing statistical data. This is especially true for MSc students in Statistics.

The intended generic learning outcomes.
On successfully completing the module students:
1. will have developed a logical, mathematical approach to solving complex problems, at an advanced level;
2. will have enhanced their ability to work with relatively little guidance, and be able to exercise initiative;
3. will have gained further organisational, computer and study skills, and be able to adapt them to new situations;
4. will be able to use scientific word processing software, such as LaTex, to present their dissertation;
5. will have produced a dissertation that effectively communicates the material to the reader;
6. will have demonstrated an ability to evaluate research work critically;
7. will have selected material from source texts, either recommended to or found by the student;

Method of Assessment

Assessment: By presentation (5%) and dissertation (95%).

Preliminary Reading

There is no general reading list for this project-based module. Literature relevant to specific project topics will be recommended by individual supervisors.

Synopsis *

The module enables students to undertake an independent piece of work in a particular area of statistics, or statistical finance/financial econometrics and to write a coherent account of the material. There is no specific syllabus for this module.

MA976 Industrial Placement Report and Presentation

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	30 (15)	100% Coursework	Wood Dr I

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:
A variety of subject-specific learning outcomes will be consolidated and extended but the particular set will vary between industrial placements.
1 Application of subject-specific skills relating to the programme of study (Mathematics, Statistics, Statistics with Finance or Applied Actuarial Science as appropriate) in a professional context.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1 Plan, work and study independently and to use relevant resources in a manner that reflects good practice, exercising initiative and personal responsibility.
2 Make effective use of general IT facilities including information retrieval skills.
3 Manage their own learning and development, including time management and organisational skills.
4 Appreciate the importance of continued professional development as part of lifelong learning.
5 Communicate technical issues clearly to specialist and non-specialist audiences.
6 Present ideas, arguments and results in the form of a well-structured written report and in a presentation that demonstrates a comprehensive understanding of techniques applicable to the placement.
7 Demonstrate at a high level the application of knowledge and skills gained through academic study in a working environment.

Method of Assessment

This module is assessed by the following. The module mark is based on:
• A Placement Report of up to 5,000 words or 15 pages in length – 50% of total module mark;
• Production of an industrial placement poster, and delivering a short presentation based on the poster – 50 % of total module mark.

Synopsis *

Students spend a period doing paid work in an organisation outside the University, usually in an industrial or commercial environment, applying and enhancing the skills and techniques they have developed and studied earlier during their degree programme. Employer evaluation, personal and professional reviews and on-line blogs are assessed.

MA977 Industrial Placement Experience

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	30 (15)	Pass/Fail Only	Wood Dr I

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:
A variety of subject-specific learning outcomes will be consolidated and extended but the particular set will vary between industrial placements.
1 Application of subject-specific skills relating to the programme of study (Mathematics, Statistics, Statistics with Finance or Applied Actuarial Science as appropriate) in a professional context.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1 deal with complex issues both systematically and creatively, and communicate their conclusions clearly to specialist and non-specialist audiences
2 demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing tasks at a professional or equivalent level
3 continue to advance their knowledge and understanding/appreciate the importance of continued professional development as part of lifelong learning
4 plan and work independently and use relevant resources in a manner that reflects good practice
5 manage their own learning and development, including time management and organisational skills
6 work effectively as a member of a team
7 demonstrate the application of knowledge and skills gained through academic study in a working environment

Method of Assessment

This module is assessed by three separate components.

• Performance and demonstrated abilities on the job, evaluated by the placement supervisor (Employer Evaluation)
• Half Yearly and End of Year reviews of personal and professional development together with an End of Year Development Plan
• On-line Blogs – Weekly for 1st month and every two months thereafter

Each of the 3 components is assessed separately on a pass / fail basis.

Synopsis *

Students spend a period of time doing paid work in an organisation outside the University, usually in an industrial or commercial environment, applying and enhancing the skills and techniques they have developed and studied in the earlier stages of their MSc programme.

The work they do is entirely under the direction of their industrial supervisor, but support is provided by the SMSAS Placement Officer or a member of the academic team. This support includes ensuring that the work they are being expected to do is such that they can meet the learning outcomes of the module.

Participation in this module is dependent on students obtaining an appropriate placement, for which support and guidance is provided through the School in the year leading up to the placement. It is also dependent on students completing the taught component of their studies. The University does not guarantee that every student will find a placement.

Students who do not obtain a placement will be required to transfer to the appropriate programme without an Industrial Placement.

MA978 Industrial Placement Experience

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	60 (30)	Pass/Fail Only	Wood Dr I

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:
A variety of subject-specific learning outcomes will be consolidated and extended but the particular set will vary between industrial placements.
1 Application of subject-specific skills relating to the programme of study (Mathematics, Statistics, Statistics with Finance or Applied Actuarial Science as appropriate) in a professional context.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1 deal with complex issues both systematically and creatively, and communicate their conclusions clearly to specialist and non-specialist audiences
2 demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing tasks at a professional or equivalent level
3 continue to advance their knowledge and understanding/appreciate the importance of continued professional development as part of lifelong learning
4 plan and work independently and use relevant resources in a manner that reflects good practice
5 manage their own learning and development, including time management and organisational skills
6 work effectively as a member of a team
7 demonstrate the application of knowledge and skills gained through academic study in a working environment

Method of Assessment

This module is assessed by three separate components.

• Performance and demonstrated abilities on the job, evaluated by the placement supervisor (Employer Evaluation)
• Half Yearly and End of Year reviews of personal and professional development together with an End of Year Development Plan
• On-line Blogs – Weekly for 1st month and every two months thereafter

Each of the 3 components is assessed separately on a pass / fail basis.

Synopsis *

Students spend a period of time doing paid work in an organisation outside the University, usually in an industrial or commercial environment, applying and enhancing the skills and techniques they have developed and studied in the earlier stages of their MSc programme.

The work they do is entirely under the direction of their industrial supervisor, but support is provided by the SMSAS Placement Officer or a member of the academic team. This support includes ensuring that the work they are being expected to do is such that they can meet the learning outcomes of the module.

Participation in this module is dependent on students obtaining an appropriate placement, for which support and guidance is provided through the School in the year leading up to the placement. It is also dependent on students completing the taught component of their studies. The University does not guarantee that every student will find a placement.

Students who do not obtain a placement will be required to transfer to the appropriate programme without an Industrial Placement.

MA979 Industrial Placement Experience

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	90 (45)	Pass/Fail Only	Wood Dr I

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:
A variety of subject-specific learning outcomes will be consolidated and extended but the particular set will vary between industrial placements.
1 Application of subject-specific skills relating to the programme of study (Mathematics, Statistics, Statistics with Finance or Applied Actuarial Science as appropriate) in a professional context.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1 deal with complex issues both systematically and creatively, and communicate their conclusions clearly to specialist and non-specialist audiences
2 demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing tasks at a professional or equivalent level
3 continue to advance their knowledge and understanding/appreciate the importance of continued professional development as part of lifelong learning
4 plan and work independently and use relevant resources in a manner that reflects good practice
5 manage their own learning and development, including time management and organisational skills
6 work effectively as a member of a team
7 demonstrate the application of knowledge and skills gained through academic study in a working environment

Method of Assessment

This module is assessed by three separate components.

• Performance and demonstrated abilities on the job, evaluated by the placement supervisor (Employer Evaluation)
• Half Yearly and End of Year reviews of personal and professional development together with an End of Year Development Plan
• On-line Blogs – Weekly for 1st month and every two months thereafter

Each of the 3 components is assessed separately on a pass / fail basis.

Synopsis *

Students spend a period of time doing paid work in an organisation outside the University, usually in an industrial or commercial environment, applying and enhancing the skills and techniques they have developed and studied in the earlier stages of their MSc programme.

The work they do is entirely under the direction of their industrial supervisor, but support is provided by the SMSAS Placement Officer or a member of the academic team. This support includes ensuring that the work they are being expected to do is such that they can meet the learning outcomes of the module.

Participation in this module is dependent on students obtaining an appropriate placement, for which support and guidance is provided through the School in the year leading up to the placement. It is also dependent on students completing the taught component of their studies. The University does not guarantee that every student will find a placement.

Students who do not obtain a placement will be required to transfer to the appropriate programme without an Industrial Placement.

MA991 Industrial Placement Experience

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn and Spring	M	120 (60)	Pass/Fail Only	Wood Dr I

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students will be able to:
A variety of subject-specific learning outcomes will be consolidated and extended but the particular set will vary between industrial placements.
1 Application of subject-specific skills relating to the programme of study (Mathematics, Statistics, Statistics with Finance or Applied Actuarial Science as appropriate) in a professional context.

The intended generic learning outcomes.
On successfully completing the module students will be able to:
1 deal with complex issues both systematically and creatively, and communicate their conclusions clearly to specialist and non-specialist audiences
2 demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing tasks at a professional or equivalent level
3 continue to advance their knowledge and understanding/appreciate the importance of continued professional development as part of lifelong learning
4 plan and work independently and use relevant resources in a manner that reflects good practice
5 manage their own learning and development, including time management and organisational skills
6 work effectively as a member of a team
7 demonstrate the application of knowledge and skills gained through academic study in a working environment

Method of Assessment

This module is assessed by three separate components.

• Performance and demonstrated abilities on the job, evaluated by the placement supervisor (Employer Evaluation)
• Half Yearly and End of Year reviews of personal and professional development together with an End of Year Development Plan
• On-line Blogs – Weekly for 1st month and every two months thereafter

Each of the 3 components is assessed separately on a pass / fail basis.

Synopsis *

Students spend a period of time doing paid work in an organisation outside the University, usually in an industrial or commercial environment, applying and enhancing the skills and techniques they have developed and studied in the earlier stages of their MSc programme.

The work they do is entirely under the direction of their industrial supervisor, but support is provided by the SMSAS Placement Officer or a member of the academic team. This support includes ensuring that the work they are being expected to do is such that they can meet the learning outcomes of the module.

Participation in this module is dependent on students obtaining an appropriate placement, for which support and guidance is provided through the School in the year leading up to the placement. It is also dependent on students completing the taught component of their studies. The University does not guarantee that every student will find a placement.

Students who do not obtain a placement will be required to transfer to the appropriate programme without an Industrial Placement.

MA995 Graphs and Combinatorics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

42-48 lectures and example classes

Learning Outcomes

The intended subject specific learning outcomes
On successful completion of this module, students will:
1 have gained knowledge of the fundamental concepts and results in graph theory and combinatorics;
2 be able to describe and solve a mathematical problem using graphs and combinatorial arguments;
3 have gained further knowledge of discrete structures in mathematics;
4 have gained a working knowledge of various fundamental graph algorithms;
5 have an ability to understand constructive proofs and to be able to use them to design algorithms.
6 have a systematic understanding of an advanced topic in graph theory or combinatorics at the forefront of the discipline.

The intended generic learning outcomes
On successful completion of this module, students will have:
1 enhanced mathematical problem solving skills;
2 gained further appreciation of proofs in mathematics;
3 gained understanding of constructive proofs;
4 strengthened their skills in designing and working with algorithms;
5 an enhanced ability to communicate complex mathematical concepts.
6 an enhanced ability to master and communicate mathematics independently.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

P. Cameron, Combinatorics, Topics, Techniques Algorithms, Cambridge Press, (1994)
L. Lovasz, J. Pelikan, and K. Vesztergombi, Discrete Mathematics: Elementary and Beyond. Springer-Verlag, (2003).
D. B. West, Introduction to Graph Theory, Prentice Hall, (1996).
R.J. Wilson, Introduction to Graph Theory, Fourth edition. Longman, Harlow, (1996).

J.A. Bondy and U.S.R. Murty, Graph Theory, Graduate Text in Math. 244, Springer-Verlag, (2008).
B. Ballobas, Modern Graph Theory, Graduate Text in Math., 184, Springer-Verlag, 1998.

Synopsis *

Combinatorics is a field in mathematics that studies discrete, usually finite, structures, such as graphs. It not only plays an important role in numerous parts of mathematics, but also has real world applications. In particular, it underpins a variety of computational processes used in digital technologies and the design of computing hardware. Among other things, this module provides an introduction to graph theory. Graphs are discrete objects consisting of vertices that are connected by edges. We will discuss a variety of concepts and results in graph theory, and some fundamental graph algorithms. Topics may include, but are not restricted to, trees, shortest paths problems, walks on graphs, graph colourings and embeddings, flows and matchings, and matrices and graphs. In addition to graphs the module may cover other topics in combinatorics such as Ramsey theory, problems in extremal set theory, enumerative problems, Principle of Inclusion and Exclusion, and the P versus NP problem.