MA501 Statistics for Insurance

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

Contact Hours

Total contact hours: 48
Private study hours: 102
Total study hours: 150

Learning Outcomes

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

1 explain basic concepts and models in decision analysis and statistics, as presented in the module, and apply them in insurance;
2 construct risk models appropriate to short term insurance contracts and make the related statistical inference;
3 describe and apply the fundamental concepts of credibility theory;
4 describe and apply the basic methodology used in rating general insurance business;
5 describe and apply techniques for analysing a delay (or run-off) triangle.

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

1 demonstrate probabilistic and statistical skills in solving financial problems;
2 demonstrate enhanced conceptual skills and logical reasoning ability;
3 demonstrate a broad understanding of the range of application of statistics to financial processes.

Method of Assessment

80% Examination, 20% 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)

Pre-requisites

Pre-requisite: MAST5007 Mathematical Statistics
Co-requisite: MAST5001 Applied Statistical Modelling 1
Or:
Pre-requisite: MAST5290 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.

MA516 Contingencies 1

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	I	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Autumn	I	15 (7.5)	70% Exam, 30% Coursework	

Contact Hours

Total contact hours: 48
Private study hours: 102
Total study hours: 150

Learning Outcomes

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

1 demonstrate systematic understanding of the mathematical techniques used to model and value cashflows which are contingent on mortality and morbidity risks;
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
cashflows which are contingent on mortality and morbidity risks;
3 demonstrate a basic understanding of recent developments in Actuarial Mathematics and the links between the theory of Actuarial Mathematics and their practical
application.

The intended generic learning outcomes. On successfully completing the module students will be able to:
1 apply a logical mathematical approach to solving problems;
2 demonstrate skills in written communication;
3 demonstrate skills in the use of relevant information technology;
4 demonstrate skills in time management, organisation and studying.

Method of Assessment

70% Examination, 30% Coursework

Preliminary Reading

Students are provided with the study notes published by the Actuarial Education Company for Subject CM1 – Actuarial Mathematics.

Pre-requisites

Prerequisite: MACT3150 or MACT4012 Financial Mathematics;
or co-requisite: MACT7150 or MACT6009 Financial Mathematics

Synopsis *

The aim of this module is to provide a grounding in the principles of modelling as applied to actuarial work – focusing particularly on deterministic models which can be used to model and value cashflows which are dependent on death, survival, or other uncertain risks. Indicative topics covered by the module include equations of value and its applications, single decrement models, multiple decrement and multiple life models. This module will cover a number of syllabus items set out in Subject CM1 – Actuarial Mathematics published by the Institute and Faculty of Actuaries.

MA525 Survival Models

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Autumn	H	15 (7.5)	70% Exam, 30% Coursework	
3	Canterbury	Autumn	H	15 (7.5)	70% Exam, 30% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

Learning Outcomes

The intended subject specific learning outcomes. On successfully completing the level 6 module students will be able to:

1 describe, interpret and discuss key aspects of survival models;
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
survival models;
3 demonstrate an appreciation of recent developments in survival models and the links between the theory of survival models and their practical application in well-defined
contexts.

The intended generic learning outcomes. On successfully completing the level 6 module students will be able to:

1 develop a logical mathematical approach to solving complex problems including cases where information/data is not complete
2 demonstrate skills in written communication to both technical and non-technical audiences,
3 demonstrate skills in the use of relevant information technology,
4 demonstrate skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Method of Assessment

70% Examination, 30% Coursework

Preliminary Reading

Study notes published by the Actuarial Education Company for Subject CS2

Pre-requisites

MACT5160 (Actuarial Mathematics 1); MAST5007 Mathematical Statistics

Synopsis *

The aim of this module is to provide a grounding in mathematical and statistical modelling techniques that are of particular relevance to survival analysis and their application to actuarial work.

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 also includes the study of various other survival models, and an introduction to machine learning. This module will cover a number of syllabus items set out in Subject CS2 – Actuarial Mathematics published by the Institute and Faculty of Actuaries.

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	

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)	70% Exam, 30% Coursework	
2	Canterbury	Spring	H	15 (7.5)	70% Exam, 30% Coursework	
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

Learning Outcomes

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

1. demonstrate systematic understanding of the mathematical techniques used to model and value cashflows which are contingent on mortality and morbidity risks;
2. demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a good level of skill in calculation and manipulation of
models used to value cashflows which are contingent on mortality and morbidity risks;
3. demonstrate an understanding of recent developments in Actuarial Mathematics and the links between the theory of Actuarial Mathematics and their practical application.

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

1 apply a logical mathematical approach to solving problems;
2 demonstrate skills in written communication to both technical and non-technical audiences;
3 demonstrate skills in the use of relevant information technology;
4 demonstrate skills in time management, organisation and studying.

Method of Assessment

70% Examination, 30% Coursework

Preliminary Reading

Students are provided with the study notes published by the Actuarial Education Company for Subject CM1 – Actuarial Mathematics.

Pre-requisites

MACT5160: Actuarial Mathematics 1

Synopsis *

The aim of this module is to provide a grounding in the principles of modelling as applied to actuarial work – focusing particularly on deterministic models which can be used to model and value cashflows which are dependent on death, survival, or other uncertain risks. Indicative topics covered by the module include equations of value and its applications, single decrement models, multiple decrement and multiple life models, pricing and reserving. This module will cover a number of syllabus items set out in Subject CM1 – Actuarial Mathematics published by the Institute and Faculty of Actuaries.

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	

Contact Hours

Total contact hours: 36
Private study hours:114
Total study hours: 150

Learning Outcomes

The intended subject specific learning outcomes. On successfully completing the level 6 module students will be able to:

1 describe, interpret and discuss the mathematics of financial derivatives;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a basic level of skill in calculation and manipulation of
financial derivatives;
3 demonstrate a basic appreciation of recent developments in the mathematics of financial derivatives and the links between the theory of the mathematics of financial
derivatives and its practical application.

The intended generic learning outcomes. On successfully completing the level 6 module students will be able to:

1 use a logical mathematical approach to solve problems;
2 solve problems and communicate in writing effectively to both a technical and non-technical audience;
3 manage their time and work independently.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Hull, John, Options, Futures and other derivatives, 8th Edition, Prentice Hall, 2012.
Baxter, Martin; Rennie, Andrew, Financial Calculus: an introduction to derivative pricing, Cambridge University Press, 1996 (E-book version also available)
Study notes published by the Actuarial Education Company for Subject CM2

Pre-requisites

Pre-requisites: MAST5007 Mathematical Statistics or alternatively students would be expected to have studied material equivalent to that covered in MAST5007.

Synopsis *

The aim of this module is to provide a grounding in the principles of modelling as applied to actuarial work – focusing particularly on the valuation of financial derivatives. These skills are also required to communicate with other financial professionals and to critically evaluate modern financial theories.

Indicative topics covered by the module include theories of stochastic investment return models and option theory.

This module will cover a number of syllabus items set out in Subject CM2 – Actuarial Mathematics published by the Institute and Faculty of Actuaries.

MA539		Financial Modelling				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	100% Coursework	

Contact Hours

Total contact hours: 36
Private study hours: 114
Total study hours: 150

Learning Outcomes

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

1 demonstrate skills in specific actuarial software and information technology (e.g. PROPHET);
2 understand the principles of specific actuarial mathematics techniques;
3 develop simple actuarial computer models to solve actuarial problems;
4 interpret and communicate the results of the models derived in 3 above.

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

1 use a logical mathematical approach to solving problems;
2 communicate material competently in writing;
3 apply relevant computing skills.

Method of Assessment

100% coursework

Preliminary Reading

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

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.

MA549		Discrete Mathematics				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	H	15 (7.5)	80% Exam, 20% Coursework	
1	Canterbury	Autumn	H	15 (7.5)	90% Exam, 10% Coursework	
1	Canterbury	Autumn	H	15 (7.5)	100% Exam	
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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

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,

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	
3	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 Matrix Lie Groups and Lie Algebras;
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: Matrix Lie
groups, Lie algebras, representations of Lie groups and Lie algebras;
3 apply a range of concepts and principles in Matrix Lie Groups and Lie Algebras theory 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

• K. Erdmann and M. Wildon: Introduction to Lie algebras. Springer Undergraduate Mathematics Series. Springer-Verlag London, Ltd., London, 2006. x+251 pp. ISBN: 978-1-84628-040-5; 1-84628-040-0
• B. Hall: Lie groups, Lie algebras, and representations. An elementary introduction. Second edition. Graduate Texts in Mathematics, 222. Springer, Cham, 2015. xiv+449 pp. ISBN: 978-3-319-13466-6; 978-3-319-13467-3

Synopsis *

• Introduction to Matrix Lie Groups: Basic examples. Matrix groups GL(n), SL(n), SO(n), Sp(n).
• Representations of SU(2): Tensor product of representations, Clebsch-Gordan series for SU(2).
• The Lie algebra of a Lie group. The exponential map.
• Introduction to Lie algebras: The Lie algebras gl(n), sl(n), so(n), sp(n). Nilpotent, solvable and semi-simple Lie algebras. The adjoint action of a group on its Lie algebra,
and of a Lie algebra on itself. Derivations.
• Representations of sl(2).

MA567 Topology

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	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 topology;
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: topological spaces, continuity, convergence, homotopy theory;
3 apply key aspects of topology 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

The module will not follow a specific text. However, the following texts cover the material.
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

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	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 orthogonal polynomial sequences and in particular classical polynomials, special functions and their properties;
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: analysis of solutions to linear differential equations with polynomial coefficients which includes their asymptotic behaviour; approximation
theory; numerical analysis techniques; mathematical physics problems; probability theory;
3 apply key aspects of orthogonal polynomials and special functions in well-defined contexts, showing judgement in the selection and application of tools and techniques;
4 show judgement in the selection and application of Maple as appropriate.

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

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

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)	80% Exam, 20% Coursework	
1	Canterbury	Autumn	H	15 (7.5)	100% Exam	
1	Canterbury	Spring	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	
1	Canterbury	Spring	H	15 (7.5)	70% Exam, 30% Coursework	
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 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

Pre-requisite: MAST4001 (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	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	
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.

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	
1	Canterbury	Autumn	H	15 (7.5)	90% Exam, 10% Coursework	
1	Canterbury	Spring	H	15 (7.5)	90% Exam, 10% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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

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.

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	

Contact Hours

Total contact hours: 13
Private study hours: 137
Total study hours: 150

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.

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: MAST6007 Mathematical Statistics, MAST6008 Applied Statistical Modelling 1

Synopsis *

This module offers 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.

MA636 Stochastic Processes

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

Contact Hours

Total contact hours: 48
Private study hours: 102
Total study hours: 150

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

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.

MA639 Time Series Modelling and Simulation

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

Contact Hours

Total contact hours: 46
Private study hours: 104
Total study hours: 150

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 *

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 residuals of a time series after estimation.
Forecasting: Holt-Winters, 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: transfer function models, vector autoregressive moving average (VARM(p,q)) models, impulse responses.
Spectral Analysis: spectral distribution and density functions, linear filters, estimation in the frequency domain, periodogram.
Simulation: generation of pseudo-random numbers, random variate generation by the inverse transform, acceptance rejection. Normal random variate generation: design issues and sensitivity analysis.

MA6507		Mathematical Statistics				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	H	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 44
Private study hours: 106
Total study hours: 150

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)

Pre-requisites

Material equivalent to that covered in the following:
MAST4006 (Mathematical Methods 1), MAST4007 (Mathematical Methods 2), MAST4009 (Probability), MAST4011 (Statistics)

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	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 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 *

In this module we study the fundamental concepts and results in game theory. We start by analysing combinatorial games, and discuss game trees, winning strategies, and the classification of positions in so called impartial combinatorial games. We then move on to discuss two-player zero-sum games and introduce security levels, pure and mixed strategies, and prove the famous von Neumann Minimax Theorem. We will see how to solve zero-sum two player games using domination and discuss a general method based on linear programming. Subsequently we analyse arbitrary sum two-player games and discuss utility, best responses, Nash equilibria, and the Nash Equilibrium Theorem. The final part of the module is devoted to multi-player games and cooperation; we analyse coalitions, the core of the game, 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	

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	Whole Year	H	15 (7.5)	70% Exam, 30% Coursework	
3	Canterbury	Whole Year	H	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 60
Private study hours: 90
Total study hours: 150

Learning Outcomes

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

1 demonstrate systematic knowledge, understanding and critical awareness of the theory related to core principles in corporate finance and financial reporting;
2 demonstrate comprehensive understanding of the complex techniques applicable to solve problems in corporate finance and financial accounting;
3 demonstrate an appreciation of 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 successfully completing the module students will be able to:

1 use a logical mathematical approach to solve complex problems including cases where information/data is not complete;
2 communicate material competently in writing to both technical and non-technical audiences;
3 apply skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Method of Assessment

70% examination, 30% coursework

Preliminary Reading

Students are provided with the study notes published by the Actuarial Education Company for Subject CB1 – Business Finance.

The following may be used for background reading:

Anne Britton, Christopher Waterston, Financial Accounting (5th edition), Pearson, 2009
Richard Brealey, Stewart Myers, Franklin Allen, Principles of Corporate Finance (12th Edition, International Student Edition), McGraw Hill 2016
Geoffrey Holmes, Alan Sugden, Paul Gee, Interpreting Company Reports and Accounts (10th edition), Prentice Hall 2008

Pre-requisites

None

Synopsis *

This module provides an introduction to the principles of corporate finance and financial reporting. It is intended for students of 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, 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
This module will cover a number of syllabus items set out in Subject CB1 – Business Finance published by the Institute and Faculty of Actuaries.
(This is a dynamic syllabus, changing regularly to reflect current practice.)

MA729 Probability and Statistics for Actuarial Science

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

Contact Hours

Total contact hours: 75
Private study hours: 225
Total number of study hours: 300

Learning Outcomes

The intended subject specific learning outcomes. On successfully completing the module students will:
1 have a systematic knowledge of probability theory and statistical inference
2 be able to use mathematical techniques to manipulate joint, marginal and conditional probability distributions, to derive distributions of transformed random variables, to
analyse associations between random variables, and study the effects of one or more explanatory variables on the response variables through linear regression modeling
3 be able to use a comprehensive range of mathematical techniques to calculate point and interval estimates of parameters and to perform tests of hypotheses
4 be able to select and apply the above techniques to critically evaluate complex real world problems and find suitable solutions.

The intended generic learning outcomes. On successfully completing the module students will:
1 have developed their understanding of probability and statistics;
2 have critically applied a range of mathematical techniques to solve complex statistical problems
3 have developed their ability to critically evaluate and abstract the essentials of problems and to formulate them mathematically
4 have developed high-level skills in numeracy and problem solving
5 have enhanced their study skills and ability to work with relatively little supervision

Method of Assessment

80% examination, 20% 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.

Hogg, R., Craig, A. and McKean, J. (2013) [Background]
Introduction to Mathematical Statistics. 7th international edition.
Pearson Education, Prentice Hall, New Jersey.
Larson, H. J. (1982) [Background]
Introduction to Probability Theory and Statistical Inference. 3rd edition.
Wiley, New York.
Spiegel, M. R, Schiller, J. and Alu Srinivasan, R. (2013) [Background]
Schaum's Outline of Probability and Statistics. 4th edition.
McGraw-Hill, New York

Pre-requisites

Prerequisite: material equivalent to that covered in MAST4006 (Mathematical Methods 1) and MAST4007 (Mathematical Methods 2).

Synopsis *

The curriculum covers parts of the professional curriculum of the Institute and Faculty of Actuaries syllabus CS1, and it introduces (and revises for some students) the essentials of probability and classical (frequentist) statistical inference.
Probability: review of elementary probability, concept of random variable, discrete and continuous probability distributions, cumulative distribution function, expectation and variance, joint distributions, marginal and conditional distributions, generating functions and transformation of random variables.
Statistics: sampling distributions, point estimation, method of moment and maximum likelihood estimation, confidence intervals, hypothesis testing, association between variables and linear regression.

MA735 Actuarial Mathematics

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	30 (15)	70% Exam, 30% Coursework	
1	Canterbury	Whole Year	M	30 (15)	70% Exam, 30% Coursework	

Contact Hours

Total contact hours: 96
Private study hours: 204
Total study hours: 300

Learning Outcomes

The intended subject specific learning outcomes. On successfully completing the module students will be able to:
1. describe, interpret and discuss mathematical techniques used to model and value cashflows which are contingent on mortality and morbidity risks;
2. show a comprehensive understanding of the complex techniques applicable to solve problems in actuarial mathematics;
3. demonstrate a critical appreciation of recent developments in Actuarial Mathematics and the links between the theory of Actuarial Mathematics and their practical
application.

The intended generic learning outcomes. On successfully completing the module students will be able to:
1. apply a logical mathematical approach to solving complex problems including cases where information/data is not complete;
2. demonstrate skills in written communication to both technical and non-technical audiences;
3. demonstrate skills in the use of relevant information technology;
4. demonstrate skills in time management, organisation and studying so that tasks can be planned and implemented at a professional level.

Method of Assessment

70% examination, 30% coursework

Preliminary Reading

Students on the MSc in Actuarial Science and International Masters in Applied Actuarial Science programmes are provided with the study notes published by the Actuarial Education Company for Subject CM1 – Actuarial Mathematics.

The following may be used for background reading:
Dickson, D.C.M., et al, Actuarial Mathematics for Life Contingent Risks 3rd edition (Cambridge University Press 2020)

Pre-requisites

Co-requisite: MACT7009 Financial Mathematics

Synopsis *

The aim of this module is to provide a grounding in the principles of modelling as applied to actuarial work – focusing particularly on deterministic models which can be used to model and value cashflows which are dependent on death, survival, or other uncertain risks. The module will include coverage of equations of value and its applications, single decrement models, multiple decrement and multiple life models. This module will cover a number of syllabus items set out in Subject CM1 – Actuarial Mathematics published by the Institute and Faculty of Actuaries.

MA7503 Communicating Mathematics

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

Contact Hours

Total contact hours: 12
Private study hours: 138
Total study hours: 150

Learning Outcomes

The intended subject specific 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.

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 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.

Pre-requisites

Students are expected to have studied material equivalent to that covered in MAST4010 (Real Analysis 1); MAST4004 (Linear Algebra); MAST4005 (Linear Mathematics); MAST4009 (Probability); MAST4011 (Statistics). Specific projects may have additional pre-requisites.

Synopsis *

There is no specific mathematical syllabus for this module; students will chose a topic in mathematics, statistics or financial mathematics from a published list on which to base their coursework assessments (different topics for levels 6 and 7). The coursework is supported by a series of workshops covering various forms of written and oral communication. These may include critically evaluating the following: a research article in mathematics, statistics or finance; a survey or magazine article aimed at a scientifically-literate but non-specialist audience; a mathematical biography; a poster presentation of a mathematical topic; a curriculum vitae; an oral presentation with slides or board; a video or podcast on a mathematical topic. Guidance will be given on typesetting mathematics using LaTeX.

MA7510 Advances in Statistics

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

Contact Hours

36 hours

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.

Pre-requisites

Pre-requisite: Students are expected to have studied material equivalent to that covered in MAST4009 (Probability); MAST4011 (Statistics); MA5007 (Mathematical Statistics) or MAST5001 (Applied Statistical Modelling 1)

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	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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;
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,
At level 7, topics will be studied and assessed to greater depth.

MA7521 Groups, Knots and Fields

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	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 Groups, Knots and Fields ;
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: groups, Sylow's Theorems, finitely generated abelian groups, Smith normal form, knots and their invariants, Galois extensions;
3 apply a range of concepts and principles in Groups, Knots and Fields theory 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

Group theory:
M. Aschbacher: Finite Group Theory (Cambridge Studies in Advanced Mathematics), Cambridge University Press, 2000
B. Baumslag and B. Chandler: Schaum's Outline of Group Theory, McGraw Hill Professional, 1968
A. Kerber, Applied Finite Group Actions, Springer, 1999
Knot theory:
C. Livingston, Knot theory, Mathematical Association of America, 1993
V. Manturov, Knot Theory, Chapman & Hall, 2004

Field theory:
John M. Howie, Fields and Galois Theory, Springer, 2006

Pre-requisites

Students are expected to have studied material equivalent to that covered in the modules MAST5003 (Groups and Symmetries); MAST5014 (Rings and Fields)

Synopsis *

• Groups: revision, presentations of groups, Sylow's theorems and applications (e.g. classification of groups)
• Finitely generated abelian groups: finite abelian groups, Smith normal form, classification, applications (e.g. systems of linear Diophantine equations)
• Knots: introduction, Reidemeister moves, knot invariants, the Abelian knot group
• Fields: revision, soluble groups, Galois Theorem, applications (e.g. impossibility of solving the quintic)

In addition, for level 7 students:
• Advanced topic such as proof of the Galois Theorem, the Jones polynomial, the Alexander polynomial, braid groups or Polya enumeration.

MA7522 Integrable Systems

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

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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.

At level 7, topics will be studied and assessed to greater depth.

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

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 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.

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

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).

Pre-requisites

Pre-requisite: Students are expected to have studied material equivalent to that covered in MAST5013 (Real Analysis 2)

Synopsis *

Metric spaces: Examples of metrics and norms, topology in metric spaces, sequences and convergence, uniform convergence, continuous maps, compactness, completeness and completions, contraction mapping theorem and applications.
Normed spaces: Examples, including function spaces, Banach spaces and completeness, finite and infinite dimensional normed spaces, continuity of linear operators and spaces of bounded linear operators, compactness in normed spaces, Arzela-Ascoli theorem, Weierstrass approximation theorem.

Additional topics, especially for level 7, may include:
• Tietze extension theorem and Urysohn's lemma
• Baire category theorem and applications
• Cantor sets, attractors and chaos

MA7527	Polynomials in Several Variables					
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 polynomials in several variables;
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: solution sets
for systems of polynomial equations and the corresponding ideals in the ring of polynomials;
3 apply a range of concepts and principles of polynomials in several variables in loosely defined contexts, showing good judgment in the selection and application of tools
and techniques;
4 make effective and well-considered use of computer calculation of Gröbner bases.

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

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

Pre-requisite: Students are expected to have studied material equivalent to that covered in MAST4001 (Algebraic Methods), MAST5003 (Groups and Symmetries), MAST5014 (Rings and Fields)

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.

Indicative syllabus:
• 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.

Level 7 students will cover additional topics such as polynomial maps between varieties.

MA7529 Statistical Learning

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

Contact Hours

Total contact hours: 36
Private study hours: 114
Total study hours: 150

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.

Pre-requisites

Pre-requisite: Students are expected to have studied material equivalent to that covered in the following modules: MAST4009 (Probability); MAST4011 (Statistics); MAST5007 (Mathematical Statistics) or MAST5001 (Applied Statistical Modelling 1)

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.

MA7544 Nonlinear Systems and Applications

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

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 qualitative analysis for nonlinear differential and difference 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: equilibra for
both nonlinear differential and difference equations and their stability, phase portraits, the existence of limit cycles;
3 apply a range of concepts and principles of nonlinear systems 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.

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

Jordan, J. W., and Simth, P., Nonlinear Ordinary Differential Equations: an introduction for scientists and engineers, Oxford University Press, Fourth Edition, 2007
Elaydi, S., An introduction to difference equations, Springer, 1999
Murray, J. D., Mathematical Biology I: An Introduction, Springer, Third Edition, 2002
Glendinning, P. A., Stability, Instability and Chaos: An Introduction to the Qualitative Theory of Differential Equations, Cambridge University Press, 1994
Kaplan, D., and Glass, L., Understanding Nonlinear Dynamics, Springer, 1995

Synopsis *

• Scalar autonomous nonlinear first-order ODEs. Review of steady states and their stability; the slope fields and phase lines.
• Autonomous systems of two nonlinear first-order ODEs. The phase plane; Equilibra and nullclines; Linearisation about equilibra; Stability analysis; Constructing phase
portraits; Applications. Nondimensionalisation.
• Stability, instability and limit cycles. Liapunov functions and Liapunov's theorem; periodic solutions and limit cycles; Bendixson's Negative Criterion; The Dulac criterion;
the Poincare-Bendixson theorem; Examples.
• Dynamics of first order difference equations. Linear first order difference equations; Simple models and cobwebbing: a graphical procedure of solution; Equilibrium points
and their stability; Periodic solutions and cycles. The discrete logistic model and bifurcations.
Level 7 Students only:
• Further applications of phase portraits and the Poincare-Bendixson theorem; Higher order difference equations.

MA776 Groups and Representations

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

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 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.

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 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).

MA790 Symmetry Methods for Differential Equations

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

Contact Hours

42 hours

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 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.
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

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 using online resources (Moodle).
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

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 MAST5005 (Linear partial differential equations), MAST5012 (Ordinary differential equations)

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.

Indicative content: symmetries of geometrical objects; symmetries of first-order ODEs; how to find Lie symmetries; differential invariants; reduction of order. At level 7, topics will be studied and assessed in greater depth.

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	
1	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 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.

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 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)

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	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 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.

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 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).

Additional reading for level 7:
G. Teschl: Topics in Real and Functional Analysis. Lecture notes available at http://www.mat.univie.ac.at/~gerald/ftp/book-fa/index.html

Pre-requisites

Pre-requisite: Students are expected to have studied material equivalent to that covered in MAST5013 (Real Analysis 2)

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	

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	

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	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	
4	Canterbury	Spring	M	15 (7.5)	80% Exam, 20% Coursework	
4	Canterbury	Spring	M	15 (7.5)	75% Exam, 25% Coursework	

Contact Hours

Total contact hours: 48
Private study hours: 102
Total study hours: 150

Learning Outcomes

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

1 show a systematic knowledge, understanding and critical awareness of economic theory
2 show a comprehensive understanding of the complex techniques applicable to solve problems in economics
3 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 successfully completing the module students will be able to:

1 demonstrate a logical mathematical approach to solving complex problems including cases where information/data is not complete
2 demonstrate skills in written communication to both technical and non-technical audiences
3 demonstrate skills in the use of relevant information technology
4 demonstrate 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

John Sloman, Dean Garratt, Jon Guest and Elizabeth Jones (2016), Economics for Business 7th Ed (Pearson)

The Actuarial Education Company Subject CB2 study notes support the above text.

Synopsis *

The aim of this module is to introduce students to core economic principles and how these could be used in a business environment to understand economic behaviour and aid decision making, and to provide a coherent coverage of economic concepts and principles. Indicative topics covered by the module include the working of competitive markets, market price and output determination, decisions made by consumers on allocating their budget and by producers on price and output, and different types of market structures and the implication of each for social welfare, the working of the economic system, governments' macroeconomic objectives, unemployment, inflation, economic growth, international trade and financial systems and financial crises.
This module will cover a number of syllabus items set out in Subject CB2 – Business Economics published by the Institute and Faculty of Actuaries.

MA820		Financial Mathematics				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	

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	Spring	M	15 (7.5)	75% Exam, 25% Coursework	
3	Canterbury	Autumn	M	15 (7.5)	60% Exam, 40% Coursework	
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

Learning Outcomes

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

1. describe, interpret and discuss key aspects of survival models;
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 survival models;
3. demonstrate an appreciation of recent developments in survival models and the links between the theory of survival models and their practical application in well-defined contexts.

Method of Assessment

60% Examination, 40% Coursework

Preliminary Reading

Study notes published by the Actuarial Education Company for Subject CT4
Modelling Mortality with Actuarial Applications, MacDonald, Richards, Currie (2018)

Synopsis *

The aim of this module is to provide a grounding in mathematical and statistical modelling techniques that are of particular relevance to survival analysis and their application to actuarial work.
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 also includes the study of various other survival models, and an introduction to machine learning. This module will cover a number of syllabus items set out in Subject CS2 – Actuarial Mathematics published by the Institute and Faculty of Actuaries.

MA826		Finance & Financial Reporting				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	15 (7.5)	75% Exam, 25% Coursework	

Contact Hours

Total contact hours: 60
Private study hours: 90
Total study hours: 150

Learning Outcomes

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

1 demonstrate systematic knowledge, understanding and critical awareness of the theory related to core principles in corporate finance and financial reporting;
2 demonstrate comprehensive understanding of the complex techniques applicable to solve problems in corporate finance and financial accounting;
3 demonstrate an appreciation of 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 successfully completing the module students will be able to:

1 use a logical mathematical approach to solve complex problems including cases where information/data is not complete;
2 communicate material competently in writing to both technical and non-technical audiences;
3 apply 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

Students on programmes: Postgraduate Diploma in Actuarial Science and International Masters in Applied Actuarial Science (Stage 1) are provided with the study notes published by the Actuarial Education Company for Subject CB1 – Finance and Financial Reporting.

The following may be used for background reading:

Anne Britton, Christopher Waterston, Financial Accounting (5th edition), Pearson, 2009
Richard Brealey, Stewart Myers, Franklin Allen, Principles of Corporate Finance (12th Edition, International Student Edition), McGraw Hill 2016
Geoffrey Holmes, Alan Sugden, Paul Gee, Interpreting Company Reports and Accounts (10th edition), Prentice Hall 2008

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.
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.
This module will cover a number of syllabus items set out in Subject CB1 – Business Finance published by the Institute and Faculty of Actuaries.
This is a dynamic syllabus, changing regularly to reflect current practice.

MA835 Financial Economics and Asset and Liability Modelling

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
3	Canterbury	Spring	M	15 (7.5)	70% Exam, 30% Coursework	
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	
4	Canterbury	Whole Year	M	15 (7.5)	70% Exam, 30% Coursework	
2	Canterbury	Spring	M	15 (7.5)	75% Exam, 25% Coursework	
3	Canterbury	Autumn	M	15 (7.5)	70% Exam, 30% Coursework	

Contact Hours

Total contact hours: 40
Private study hours: 110
Total study hours: 150

Learning Outcomes

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

1 describe, interpret and discuss key aspects and concepts involved in financial economics, and asset and liability models;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve complex problems using a high level of skill in calculation and manipulation
of financial economics, and asset and liability models;
3 demonstrate an appreciation of recent developments in financial economics and modelling and the links between the theory of these topics and their practical application.
4 apply the principles of financial economics and asset and liability modelling to complex financial instruments.

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

1 use a logical mathematical approach to solve complex problems;
2 solve problems and communicate in writing effectively to both a technical and non-technical audience;
3 manage their time and work independently;
4 demonstrate a high level of higher order numeracy and communication skills.

Method of Assessment

Main Assessment Methods
Examination 70%, Coursework 30%

Preliminary Reading

David Hillier, Mark Grinblatt, Sheridan Titman, 2012. Financial markets and corporate strategy, McGraw-Hill Higher Education, London.

Martin Baxter, Andrew Rennie, 1996. Financial Calculus: An Introduction to Derivative Pricing, Cambridge University Press, Cambridge.

Students on the BSc Actuarial Science programmes are provided with the study notes published by the Actuarial Education Company for Subject CM2 – Actuarial Mathematics 2.

Pre-requisites

Co-requisites:
MAST7290 Probability and Statistics for Actuarial Science 2 or alternatively students would be expected to have studied material equivalent to that covered in MAST7290.

Synopsis *

The aim of this module is to provide a grounding in the principles of modelling as applied to actuarial work – focusing particularly on stochastic asset liability models. These skills are also required to communicate with other financial professionals and to critically evaluate modern financial theories.
Indicative topics covered by the module include theories of financial market behaviour, measures of investment risk, stochastic investment return models, asset valuations, and liability valuations.

The additional 4 contact hours for level 7 students will be devoted to applications of the principles of financial economics and asset and liability modelling to complex financial instruments.

This module will cover a number of syllabus items set out in Subject CM2 – Actuarial Mathematics published by the Institute and Faculty of Actuaries.

MA836	Stochastic Processes					
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	

Contact Hours

Total contact hours: 48
Private study hours: 102
Total study hours: 150

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 concepts involved in stochastic modelling;
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: random walks,
discrete and continuous time Markov chains, queues and branching processes;
3 apply a range of concepts and principles in stochastic modelling 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 make effective use of information technology skills such as online resources (Moodle);
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

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.

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.

In addition, level 7 students will study more complex queuing systems and continuous-time branching processes.

MA837 Mathematics of Financial Derivatives

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	75% Exam, 25% Coursework	
2	Canterbury	Spring	M	15 (7.5)	70% Exam, 30% Coursework	
3	Canterbury	Spring	M	15 (7.5)	70% Exam, 30% Coursework	

Contact Hours

Total contact hours: 40
Private study hours: 110
Total study hours: 150

Learning Outcomes

On successfully completing the module students will be able to:
1 describe, interpret and discuss key aspects and concepts involved in the mathematics of financial derivatives;
2 demonstrate the capability to deploy established approaches accurately to analyse and solve complex problems using a high level of skill in calculation and manipulation
of financial derivatives;
3 demonstrate an appreciation of recent developments in the mathematics of financial derivatives and the links between the theory of the mathematics of financial
derivatives and its practical application;
4 apply the principles of mathematics of financial derivatives to complex financial instruments.

Method of Assessment

70% Exam, 30% Coursework

The coursework mark alone will not be sufficient to demonstrate the student's level of achievement on the module.

Preliminary Reading

Hull, John, Options, futures and other derivatives, 8th Edition, Prentice Hall, 2012.
Baxter, Martin; Rennie, Andrew, Financial Calculus : an introduction to derivative pricing, Cambridge University Press, 1996 (E-book version also available)
Study notes published by the Actuarial Education Company for Subject CM2.

Pre-requisites

Co-requisites: MAST7290 Probability and Statistics for Actuarial Science 2 or alternatively students would be expected to have studied material equivalent to that covered in MAST7290.

Synopsis *

The aim of this module is to provide a grounding in the principles of modelling as applied to actuarial work – focusing particularly on the valuation of financial derivatives. These skills are also required to communicate with other financial professionals and to critically evaluate modern financial theories.

Indicative topics covered by the module include theories of stochastic investment return models and option theory.

The additional 4 contact hours for level 7 students will be devoted to applications of the principles of option pricing techniques, valuation methods and hedging techniques for complex financial derivative concepts.

This module will cover a number of syllabus items set out in Subject CM2 – Actuarial Mathematics published by the Institute and Faculty of Actuaries.

MA840		Financial Modelling				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	15 (7.5)	100% Coursework	

Contact Hours

Total contact hours: 36
Private study hours: 114
Total study hours: 150

Learning Outcomes

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

1 demonstrate skills in specific actuarial software and information technology (e.g. PROPHET);
2 understand the principles of specific actuarial mathematics techniques;
3 develop simple actuarial computer models to solve actuarial problems;
4 interpret and communicate the results of the models derived in the above.

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

1 apply a logical mathematical approach to solving problems.
2 demonstrate skills to communicate competently in writing;
3 apply the relevant computing skills to solving problems and communicating solutions.

Method of Assessment

100% coursework

Preliminary Reading

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

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	

Contact Hours

Total contact hours: 38
Private study hours: 112
Total study hours: 150

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 computational statistics;
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: Numerical
aspects of maximum likelihood estimation, EM algorithm and simulation methods, including advanced techniques;
3. apply a range of concepts and principles in computational statistics in loosely defined contexts, showing good judgment in the selection and application of tools and
techniques;
4. write R programs for complex applications, making 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 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

Morgan, B. J. T. (2009) Applied Stochastic Modelling, Chapman and Hall.

Pre-requisites

Pre-requisite: None
Co-requisite: MAST8810 (Probability and Classical Inference), MAST8820 (Advanced Regression Modelling)

Synopsis *

Statistics methods contribute significantly to areas such as biology, ecology, sociology and economics. The real data collected does not always follow standard statistical models. This module looks at modern statistical models and methods that can be utilised for such data, making use of R programs to execute these methods.
Indicative module content: Motivating examples; model fitting through maximum likelihood for specific examples; function optimization methods; profile likelihood; score tests; Wald tests; confidence interval construction; latent variable models; EM algorithm; mixture models; simulation methods; importance sampling; kernel density estimation; Monte Carlo inference; bootstrap; permutation tests; R programs.
In addition, for level 7 students: advanced EM algorithm methods, advanced simulation methods, writing R programs for advanced methods and applications.

MA867 Project

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	M	60 (30)	95% Project, 5% Coursework	
3	Canterbury	Whole Year	M	60 (30)	100% Coursework	

Contact Hours

Total contact hours: 14
Private study hours: 586
Total study hours: 600

Learning Outcomes

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

1 demonstrate the relationship of the material to background material and to more advanced material;
2 write a coherent account of an area of Statistics, with particular reference to applications in Finance, if appropriate;
3 perform statistical analyses that show the depth of student understanding of the statistical methods relevant to the topic.
4 present complex analyses and draw appropriate conclusions with clarity and accuracy;
5 demonstrate understanding of theoretical and practical aspects of analysing statistical data.
6 use the text-processing software LaTex to prepare presentation slides and to present their dissertation.

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

1 apply a logical, mathematical approach to solving complex problems, at an advanced level;
2 work with relatively little guidance, and be able to exercise initiative;
3 utilise advanced organisational, computer and study skills, and be able to adapt them to new situations;
4 use scientific word processing software, such as LaTex, to present their dissertation;
5 produce a dissertation that effectively communicates the material to the reader;
6 demonstrate an ability to evaluate research work critically;
7 select appropriate material from complex 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.

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.

MA871 Asymptotics and Perturbation Methods

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

Contact Hours

42

Learning Outcomes

The intended subject specific learning outcomes. On successfully completing the level 7 module students will be able to:
1 demonstrate a systematic understanding of the use of asymptotic techniques in the study of integrals and differential equations;
2 critically apply the techniques to obtain asymptotic approximations of various types of integrals and approximate solutions of linear differential equation in complex situations;
3 demonstrate a good understanding of the techniques of matched asymptotic expansions for singular perturbation and boundary layer problems;
4 make effective use of WKB (Wentzel-Kramers-Brillouin), multiple scales and related methods to obtain asymptotic expansions of solutions of some differential equations.

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 using online resources (Moodle);
7 demonstrate an increased level of skill in numeracy and computation.

Method of Assessment

80% Examination, 20% coursework

Preliminary Reading

C M Bender and S A Orszag, "Advanced Mathematical Methods for Scientists and Engineers I: Asymptotic Methods and Perturbation Theory", Springer-Verlag, New York (1999)
J D Murray, "Asymptotic Analysis", Springer-Verlag, New York (1997)
M H Holmes, "Introduction to Perturbation Methods", Second Edition, Springer, New York (2013)

Pre-requisites

Synopsis *

The lectures will introduce students to asymptotic and perturbation methods for the approximate evaluation of integrals and to obtaining approximations for solutions of ordinary differential equations. These methods are widely used in the study of physically significant differential equations which arise in Applied Mathematics, Physics and Engineering. The material is chosen so as to demonstrate a range of the Mathematical techniques available and to illustrate some different applications which are amenable to such analysis.
The indicative syllabus is:
• Asymptotics. Ordering symbols. Asymptotic sequences, expansions and series. Differentiation and integration of asymptotic expansions. Dominant balance. Solution of algebraic and transcendental equations.
• Asymptotic evaluation of integrals. Integration by parts. Laplace's method and Watson's lemma. Method of stationary phase.
• Approximate solution of linear differential equations. Classification of singular points. Local behaviour at irregular singular points. Asymptotic expansions in the complex plane. Stokes phenomena: Stokes and anti-Stokes lines, dominance and sub-dominance. Connections between sectors of validity. Airy functions.
• Matched asymptotic expansions. Regular and singular perturbation problems. Asymptotic matching. Boundary layer theory: inner, outer and intermediate expansions and limits.
• WKB method. Schrödinger equation and Sturm-Liouville problems. Turning points.
• Multiple scales analysis and related methods. Secular terms. Multiple scales method. Method of strained coordinates (Lindstedt--Poincaré method).

Level 7 Students will study selected topics in greater depth than level 6 students.

MA881 Probability and Classical Inference

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

Contact Hours

Total contact hours: 36
Private study hours: 114
Total study hours: 150

Learning Outcomes

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

1 demonstrate a systematic understanding of probability and frequentist statistical inference;
2 use a comprehensive range of relevant concepts and principles;
3 select and apply these to solve advanced problems in probability and statistical inference, using a variety of methods.

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

1 apply a logical, mathematical approach to their work, identifying the assumptions made and the conclusions drawn;
2 solve challenging problems.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

BICKEL, P.J. and DOKSUM, K. (2001). Mathematical Statistics: Basic Ideas and Selected Topics, Volume 1, 2nd edition. London: Prentice-Hall International
CASELLA, G. and BERGER, R. L. (2002). Statistical Inference, 2nd Edition. Pacific Grove, CA: Duxbury.
FELLER, W. (1967). An Introduction to Probability Theory and its Applications, Volume 1, New York: Wiley.
HOGG, R., McKEAN, J. and CRAIG. A. (2014). Introduction to Mathematical Statistics. 7th International Edition. Harlow, Essex: Pearson Education.
ROSS, S.M. (2014). A First Course in Probability, 9th International Edition. Harlow, Essex: Pearson Education.

Synopsis *

This course introduces (and revises for some students) the essentials of probability and classical (frequentist) statistical inference, which provide the backbone for later modules.
Syllabus: Probability: axioms, marginal, joint and conditional distributions, Bayes theorem, important distributions, generating functions and various modes of convergence. Classical Inference: Sampling distributions. Point estimation: consistency, Cramer-Rao inequality, efficiency, sufficiency, minimum variance unbiased estimators. Likelihood. Methods of estimation. Hypothesis tests: maximum likelihood-ratio test, Wald and score tests, profile and test-based confidence intervals.

MA882 Advanced Regression Modelling

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

Contact Hours

Total contact hours: 30
Private study hours: 120
Total study hours: 150

Learning Outcomes

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

1 demonstrate 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;
2 interpret the results of analysis, and communicate these clearly and concisely to other statisticians and to non-statisticians;
3 demonstrate an appreciation of the limitations of standard regression and analysis of variance models for discrete data, and 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 successfully completing the module students will be able to:

1 apply a logical, mathematical approach to their work;
2 appropriately manipulate data for regression analysis;
3 demonstrate an appreciation of 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 *

Linear model. Least squares. General linear model; simple and multiple regression, polynomial regression. Model selection, residuals, outliers, diagnostics. Analysis of variance. Generalised linear model.

Discrete data analysis. Review of Binomial, Poisson, negative binomial and multinomial distributions. Properties, estimation, hypothesis tests.

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
2	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 36
Private study hours: 114
Total study hours: 150

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 Bayesian Statistics;
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: derivation of posterior distributions; computation of posterior summaries, including the predictive distribution; construction of Bayesian hierarchical models and their estimation using Markov chain Monte Carlo methods; critical evaluation and interpretation of software output.
3 apply a range of concepts and principles in Bayesian Statistics in loosely defined contexts, showing good judgement in the selection and application of tools and techniques;
4 show judgement in the selection and application of R and WinBugs/OpenBugs.

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 R and WinBugs/OpenBugs, online resources (Moodle), internet communication.
7 communicate technical material competently
8 demonstrate an increased level of skill in numeracy and computation

Method of Assessment

80% examination and 20% coursework

Preliminary Reading

A.F.M. Smith and Bernardo, J.M. (1994). Bayesian Theory. Wiley.
A. Gelman, J.B. Carlin, H.S. Stern, D.B. Dunson, A. Vehtari and D.B. Rubin (2014). Bayesian Data Analysis. 3rd Edition, Chapman & Hall/CRC Texts in Statistical Science.
D. Gamerman and H.F. Lopes (2006). Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference. 2nd Edition, Taylor and Francis.

Pre-requisites

For undergraduate programmes:
Pre-requisite: MAST5007: Mathematical Statistics

For postgraduate programmes:
Co-requisite: MAST7077: Probability and Classical Inference

Synopsis *

Bayes Theorem for density functions; Conjugate models; Predictive distribution; Bayes estimates; Sampling density functions; Gibbs and Metropolis-Hastings samplers; Winbugs/OpenBUGS; Bayesian hierarchical models; Bayesian model choice; Objective priors; Exchangeability; Choice of priors; Applications of hierarchical models.

MA884		Principles of Data Collection				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

42 hours

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 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.

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 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.

Pre-requisites

Students are expected to have studied material covered equivalent to that covered in the following modules:

MAST4009 (Probability), MAST4011 (Statistics) and at least one of MAST5007 (Mathematical Statistics) and MAST5001 (Applied Statistical Modelling 1)

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	Whole Year	M	15 (7.5)	90% Exam, 10% Coursework	
2	Canterbury	Whole Year	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 30
Private study hours: 120
Total study hours: 150

Learning Outcomes

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

1 will have a critical appreciation of the importance of statistics in different areas of current relevance;
2 will have an appreciation of actuarial areas of application in which statistical methods play a vital role, and of their importance;
3 will have an appreciation of the development of specialised methods of stochastic analysis for actuarial areas of application;
4 will be able to synthesise knowledge, and to appreciate links between disparate subject areas;
5 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 successfully completing the module students will be able to:

1 will have a systematic understanding of the role of logical argument;
2 will be able to evaluate research work critically;
3 will have technical expertise, particularly in relation to financial problems .
4 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

Co-requisite: MAST8810: Probability and Classical Inference

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 Financial Econometrics

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

Contact Hours

Total contact hours: 40
Private study hours: 110
Total study hours: 150

Learning Outcomes

The intended subject specific learning outcomes. On successfully completing the 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.

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 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 (mMoodle);
7 communicate technical and non-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 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

Pre-requisites: Students are expected to have studied material equivalent to that covered in MAST4009 Probability, MAST4011 Statistics, MAST5001 Applied Statistical Modelling and MAST5007 Mathematical Statistics

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.

MA909		Enterprise Risk Management				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

Standard Delivery - Total contact hours: 72
Tutorial Delivery - Total contact hours: 36

Teaching methods will differ according to the number of students registered on the module. The standard format, for more than 6 students registered:

Learning Outcomes

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

1 Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Enterprise Risk Management in the context of current professional actuarial practice.
2 Demonstrate knowledge and understanding of complex current issues in Enterprise Risk Management in the context of current professional actuarial practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module.
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of Enterprise Risk Management in various contexts.
6 Demonstrate skill in solving problems in Enterprise Risk Management by various appropriate methods.
7 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.
8 Demonstrate understanding of the current practical applications of the module material.

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

1 Demonstrate ability for logical argument.
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 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.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills.
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

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

The students will be provided with the study notes published by the Actuarial Education Company for Subject ST9 – Enterprise Risk Management.

Pre-requisites

Co-requisite: MACT9210 Actuarial Risk Management 1 and MACT9220 Actuarial Risk Management 2

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	Whole Year	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

Standard Delivery - Total contact hours: 72
Tutorial Delivery - Total contact hours: 36

Teaching methods will differ according to the number of students registered on the module. The standard format, for more than 6 students registered:

Learning Outcomes

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

1 Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Life Insurance in the context of current professional actuarial practice.
2 Demonstrate knowledge and understanding of complex current issues in Life Insurance in the context of current professional actuarial practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module.
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of Life Insurance in various contexts.
6 Demonstrate skill in solving problems in Life Insurance by various appropriate methods.
7 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.
8 Demonstrate understanding of the current practical applications of the module material.

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

1 Demonstrate ability for logical argument.
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 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.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills.
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students will be provided with the study notes published by the Actuarial Education Company for Subject SP2 – Life Insurance. These are ordered from the Company by the Lecturer.

Pre-requisites

Co-requisite: MACT9210: Actuarial Risk Management 1, MACT9220 Actuarial Risk Management 2

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.

MA914		Pensions and Other Benefits				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

Standard Delivery - Total contact hours: 72
Tutorial Delivery - Total contact hours: 36

Teaching methods will differ according to the number of students registered on the module. The standard format, for more than 6 students registered:

Learning Outcomes

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

1 Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Pensions and Other Benefits in the context of current professional actuarial practice.
2 Demonstrate knowledge and understanding of complex current issues in Pensions and Other Benefits in the context of current professional actuarial practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module.
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of Pensions and Other Benefits in various contexts.
6 Demonstrate skill in solving problems in Pensions and Other Benefits by various appropriate methods.
7 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.
8 Demonstrate understanding of the current practical applications of the module material.

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

1 Demonstrate ability for logical argument.
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 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.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills.
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students will be provided with the study notes published by the Actuarial Education Company for Subject ST4 – Pensions and Other Benefits. These are ordered from the Company by the Lecturer.

Pre-requisites

Co-requisite: MACT9210 Actuarial Risk Management 1 and MACT9220 Actuarial Risk Management 2

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.

To follow professional curriculum of the Faculty and Institute of Actuaries examination ST4 – https://www.actuaries.org.uk/studying/plan-my-study-route/fellowshipassociateship/specialist-technical-subjects. This is a dynamic syllabus, changing regularly to reflect current practice.

MA915		Finance and Investment				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

Standard Delivery - Total contact hours: 72
Tutorial Delivery - Total contact hours: 36

Teaching methods will differ according to the number of students registered on the module. The standard format, for more than 6 students registered.

Learning Outcomes

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

1 Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Finance and Investment in the context of current professional actuarial
practice.
2 Demonstrate knowledge and understanding of complex current issues in Finance and Investment in the context of current professional actuarial practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module.
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of Finance and Investment in various contexts.
6 Demonstrate skill in solving problems in Finance and Investment by various appropriate methods.
7 Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of Finance and Investment and their application to solving problems in
that subject.
8 Demonstrate understanding of the current practical applications of the module material.

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

1 Demonstrate ability for logical argument.
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 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.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills.
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students will be provided with the study notes published by the Actuarial Education Company for Subject SP5 – Investment and Finance. These are ordered from the Company by the School.

Pre-requisites

Co-requisite: MACT9210 Actuarial Risk Management 1 and MACT9220 Actuarial Risk Management 2

Synopsis *

The 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 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.

To follow professional curriculum of the Faculty and Institute of Actuaries examination SP5 –
https://www.actuaries.org.uk/studying/curriculum/investment-and-finance.
This is a dynamic syllabus, changing regularly to reflect current practice.

MA916		Derivative Securities				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

Standard Delivery - Total contact hours: 72
Tutorial Delivery - Total contact hours: 36

Teaching methods will differ according to the number of students registered on the module. The standard format, for more than 6 students registered.

Learning Outcomes

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

1 Demonstrate knowledge and understanding of complex techniques applicable to solve problems in Derivative Securities in the context of current professional actuarial practice.
2 Demonstrate knowledge and understanding of complex current issues in Derivative Securities in the context of current professional actuarial practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module.
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of Derivative Securities in various contexts.
6 Demonstrate skill in solving problems in Derivative Securities by various appropriate methods.
7 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.
8 Demonstrate understanding of the current practical applications of the module material.

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

1 Demonstrate ability for logical argument.
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 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.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills.
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The following textbooks are recommended:
JC Hull: Options, Futures and Other Derivatives 6th Edition (Prentice Hall)
Baxter & Rennie: Financial Calculus (Cambridge University Press 1997)

The students will be provided with the study notes published by the Actuarial Education Company for Subject SP6. These are ordered from the Company by the Lecturer.

Pre-requisites

Co-requisite: MA921 Actuarial Risk Management 1 and MA922 Actuarial Risk Management 2

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.

To follow professional curriculum of the Faculty and Institute of Actuaries examination SP6 –
https://www.actuaries.org.uk/studying/curriculum/investment-and-finance.
This is a dynamic syllabus, changing regularly to reflect current practice.

MA917 General Insurance Reserving and Capital Modelling

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
3	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	
2	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

Standard Delivery - Total contact hours: 72
Tutorial Delivery - Total contact hours: 36

Teaching methods will differ according to the number of students registered on the module. The standard format, for more than 6 students registered.

Learning Outcomes

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

1 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.
2 Demonstrate knowledge and understanding of complex current issues in General Insurance – Reserving and Capital Modelling in the context of current professional actuarial practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module.
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of General Insurance – Reserving and Capital Modelling in various contexts.
6 Demonstrate skill in solving problems in General Insurance – Reserving and Capital Modelling by various appropriate methods.
7 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.
8 Demonstrate understanding of the current practical applications of the module material.

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

1 Demonstrate ability for logical argument.
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 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.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills.
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students will be provided with the study notes published by the Actuarial Education Company for Subject ST7 – General Insurance – Reserving and Capital Modelling. These are ordered from the Company by the Lecturer.

Pre-requisites

Co-requisite: MACT9210 Actuarial Risk Management 1 and MACT9220 Actuarial Risk Management 2

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.

To follow professional curriculum of the Faculty and Institute of Actuaries examination ST7 – https://www.actuaries.org.uk/studying/plan-my-study-route/fellowshipassociateship/specialist-technical-subjects. This is a dynamic syllabus, changing regularly to reflect current practice.

MA918 General Insurance - Premium Rating

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	
3	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

Standard Delivery - Total contact hours: 72
Tutorial Delivery - Total contact hours: 36

Teaching methods will differ according to the number of students registered on the module. The standard format, for more than 6 students registered.

Learning Outcomes

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

1 Demonstrate knowledge and understanding of complex techniques applicable to solve problems in General Insurance – Pricing in the context of current professional
actuarial practice.
2 Demonstrate knowledge and understanding of complex current issues in General Insurance – Pricing in the context of current professional actuarial practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module.
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of General Insurance – Premium Rating in various contexts.
6 Demonstrate skill in solving problems in General Insurance – Premium Rating by various appropriate methods.
7 Demonstrate skills in the specific mathematical and statistical techniques used in the actuarial practice of General Insurance – Pricing and their application to
solving problems in that subject.
8 Demonstrate understanding of the current practical applications of the module material.

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

1 Demonstrate ability for logical argument.
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 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.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills.
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

The students will be provided with the study notes published by the Actuarial Education Company for Subject SP8 – General Insurance – Pricing. These are ordered from the Company by the Lecturer.

Pre-requisites

Co-requisite: MACT9210 Actuarial Risk Management 1 and MACT9220 Actuarial Risk Management 2

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; aggregate claim distribution methods; 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.
To follow professional curriculum of the Faculty and Institute of Actuaries examination SP8 –
https://www.actuaries.org.uk/studying/plan-my-study-route/fellowshipassociateship/specialist-technical-subjects. This is a dynamic syllabus, changing regularly to reflect current practice.

MA921 Actuarial Risk Management 1

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

Contact Hours

Total contact hours: 72
Private study hours: 228
Total study hours: 300

Learning Outcomes

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

1 Demonstrate the ability to apply a wide range of key actuarial concepts in simple traditional and non-traditional situations.
2 Demonstrate knowledge and understanding of complex techniques applicable to solve problems using core actuarial concepts in the context of current professional actuarial
practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of core actuarial concepts in various contexts.
6 Demonstrate skill in solving problems using core actuarial concepts by various appropriate methods.
7 Demonstrate understanding of the current practical applications of the module material

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

1 Demonstrate ability for logical argument
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills.
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.
10 Demonstrate the ability to produce written documents; undertake online research; communicate using e-mail.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Study notes published by the Actuarial Education Company for subject CP1.
Bellis, Clare; Lyon, Richard; Klugman, Stuart; Shepherd, John: Understanding Actuarial Management: the actuarial control cycle, The Institute of Actuaries of Australia and the Society of Actuaries (Second Edition) 2010.

Pre-requisites

Co-requisite with MA922 Actuarial Risk Management 2

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;
* 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.

MA922		Actuarial Risk Management 2				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
4	Canterbury	Whole Year	M	30 (15)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 72
Private study hours: 228
Total study hours: 300

Learning Outcomes

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

1 Demonstrate the ability to apply a wide range of key actuarial concepts in simple traditional and non-traditional situations.
2 Demonstrate knowledge and understanding of complex techniques applicable to solve problems using core actuarial concepts in the context of current professional actuarial
practice.
3 Demonstrate a high level of understanding of the main body of knowledge for the module
4 Demonstrate skill in calculation and manipulation of the material written within the module.
5 Apply a range of concepts and principles of core actuarial concepts in various contexts.
6 Demonstrate skill in solving problems using core actuarial concepts by various appropriate methods.
7 Demonstrate understanding of the current practical applications of the module material

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

1 Demonstrate ability for logical argument
2 Demonstrate ability to work with relatively little guidance.
3 Demonstrate high-level problem-solving skills, relating to qualitative and quantitative information, demonstrating self-direction and originality of thought.
4 Demonstrate communications skills, covering both written and oral communication, with the ability to communicate clearly to both specialist and non-specialist audiences.
5 Demonstrate judgemental skills.
6 Demonstrate numeracy and computational skills
7 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.
8 Demonstrate study skills needed for continuing professional development.
9 Demonstrate decision-making skills in complex situations.
10 Demonstrate the ability to produce written documents; undertake online research; communicate using e-mail.

Method of Assessment

80% Examination, 20% Coursework

Preliminary Reading

Study notes published by the Actuarial Education Company for subject CP1.

Bellis, Clare; Lyon, Richard; Klugman, Stuart; Shepherd, John: Understanding Actuarial Management: the actuarial control cycle, The Institute of Actuaries of Australia and the Society of Actuaries (Second Edition) 2010.

Pre-requisites

Co-requisite: MACT9210 Actuarial Risk Management 1

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.

MA923 Introduction to Actuarial Research

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Whole Year	M	15 (7.5)	100% Coursework	
1	Canterbury	Whole Year	M	15 (7.5)	50% Coursework, 50% Project	

Contact Hours

Total contact hours: 26
Private study hours 124
Total study hours: 150

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;

The intended generic learning outcomes. On successfully completing the module students will be able to:
1. demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing analysis of unfamiliar material at a professional level;
2. use and develop relevant computing skills at a high level, including use of appropriate document preparation and word-processing packages;
3. demonstrate the ability to communicate conclusions clearly to an appropriate audience;
4. demonstrate a capability for independent research and problem solving skills;
5. demonstrate intellectual independence through the exercise of initiative and personal responsibility, and an ability for independent learning and time management required for continuing professional development;
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

100% Coursework

Preliminary Reading

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. (2017) Loss Coverage: Why Insurance Works Better with Some Adverse Selection. Cambridge University Press.
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

MACT9210 Actuarial Risk Management 1 and MACT9530 Communications are co-requisite modules

Synopsis *

Scientific word-processing and computing: 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 module. Scientific word-processing will be taught using LaTex. Students will also be introduced to the statistical software R, and refresh their knowledge of statistical methods relevant to actuarial research.
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.

MA924		Short Project (Actuarial Research)				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Spring	M	15 (7.5)	100% Coursework	

Contact Hours

Meeting with project supervisor: 6 hours
Independent learning hours: 144 hours
Total study hours: 150 hours

Learning Outcomes

The intended subject specific learning outcomes. On successfully completing the module students will be able to:
1. produce a research report using LaTex;
2. produce research that demonstrates high level skills in relevant computing utilities and the statistical package R;
3. produce research that demonstrates the ability to analyse data, evaluate and develop models, and interpret the results appropriately; and
4. produce research that demonstrates the ability to apply appropriate mathematical, statistical and actuarial concepts and techniques in a particular topical area of actuarial research.

The intended generic learning outcomes. On successfully completing the module students will be able to:
1. demonstrate self-direction and originality in tackling and solving problems, and act autonomously in planning and implementing analysis of unfamiliar material at a professional level
2. demonstrate relevant computing skills at a high level, including use of appropriate document preparation and word-processing packages;
3. demonstrate the ability to communicate conclusions clearly to an appropriate audience;
4. demonstrate a capability for independent research and problem-solving skills;
5. demonstrate intellectual independence through the exercise of initiative and personal responsibility, and an ability for independent learning and time management required for continuing professional development;
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, and show an ability to synthesise information and incorporate ideas in support of an academic argument.

Method of Assessment

70% project, 30% coursework

Preliminary Reading

Porteous, B. and Tapadar, P. (2005). Economic Capital and Financial Risk Management for Financial Services Firms and Conglomerates. Palgrave Macmillan.
Sweeting, P. (2017). Financial Enterprise Risk Management (2nd Ed). Cambridge University Press.
Thomas, R.G. (2017) Loss Coverage: Why Insurance Works Better with Some Adverse Selection. Cambridge University Press.
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 Actuarial Risk Management 1, MA953 Communications and MA923 Introduction to Actuarial Research are co-requisite modules

Synopsis *

Students, either individually or as part of a group, will be assigned a project on an area of actuarial research. For each project, the students will be required to process and analyse information, form conclusions, and produce an individual written report in LaTex that contains a review of existing literature on the particular topic, and to produce a piece of work in the assigned area of research and a coherent account thereof in LaTex, either as an individual or as part of a group.

MA934 Probability and Statistics for Finance

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

MA942		Data Science with R				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
1	Canterbury	Autumn	M	15 (7.5)	75% Exam, 25% Coursework	

Contact Hours

Total contact hours: 44 hours
Private study hours: 106 hours
Total number of study hours: 150 hours

Learning Outcomes

The intended subject specific learning outcomes. On successfully completing the module students will be able to:
1 demonstrate systematic understanding of the concepts involved in machine learning;
2 demonstrate the capability to solve complex problems using a high level of skill in calculation and manipulation of the material in the following areas: Supervised learning
with R; data science for actuarial science, finance and other areas.
3 apply a range of concepts and principles in supervised learning 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 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 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

75% examination, 25% coursework

Preliminary Reading

Bishop, C. M. (2006), Pattern Recognition and Machine Learning. Springer, New York
James, G, Witten, D., Hastie, T., Tibshirani, R. (2013) Introduction to Statistical Learning. Springer, New York.
Sweeting, P. (2011) Financial Enterprise Risk Management. Cambridge University Press. Cambridge.

Pre-requisites

None

Synopsis *

Introduction: Machine learning and data visualisation with R.
Classification and prediction: Generalised linear model (GLM), linear discrimination analysis (LDA), k-nearest neighbors (KNN). R-based worked examples.
Resampling methods: Cross-validation (CV) and bootstrap. R-based worked examples.
Regression tree-based methods: Classification and regression trees (CART), bagging, random forests and boosting. R-based worked examples.
Support vector machines (SVM): Support vector classifier, regression SVM. R-based worked examples.
Machine Learning in Action:
(a) Biomedical and health data analysis;
(b) Bond default data analysis;
(c) Insurance data analysis;
(d) Financial data analysis;
(e) Other big data analysis.

MA950 Prophet

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

Contact Hours

Total contact hours 36:
Private study hours: 114
Total study hours: 150

Learning Outcomes

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

1 demonstrate skills in specific actuarial software and information technology (e.g. PROPHET).
2 understand the principles of specific actuarial mathematics techniques.

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

1 solve actuarial problems using appropriate computer techniques and demonstrate skills using appropriate information technology.

Method of Assessment

100% coursework

PROPHET 1 - Test 1 Computer based test 60 minutes 50%
PROPHET 1 - Test 2 Computer based test 60 minutes 50%

Preliminary Reading

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

Pre-requisites

None

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. Outline syllabus includes: overview of the uses and applications of PROPHET; introduction on how to use the software package (including security implications); using Example Profit Test 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	Autumn	M	15 (7.5)	100% Coursework	
2	Canterbury	Spring	M	15 (7.5)	100% Coursework	
2	Canterbury	Spring	M	15 (7.5)	100% Coursework	

Contact Hours

Total contact hours: 36
Private study hours: 114
Total study hours: 150

Learning Outcomes

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

1 demonstrate high level skills in specific actuarial software and information technology (e.g. PROPHET).
2 understand advanced principles of specific actuarial mathematics techniques.

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

1 solve actuarial problems using appropriate computer techniques and demonstrate skills using appropriate information technology.

Method of Assessment

Main assessment methods

PROPHET 2 - Test 1 Computer based test 60 minutes 50%
PROPHET 2 - Test 2 Computer based test 60 minutes 50%

Preliminary Reading

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

Pre-requisites

MACT9500: PROPHET 1

Synopsis *

This module builds on the knowledge of the use of PROPHET introduced to students in MACT9500 – PROPHET 1. 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.

MA952 Financial Modelling

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

Contact Hours

Contact hours: 36
Private Study hours 114
Total study hours 150

Learning Outcomes

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

1 demonstrate a systematic understanding of the principles of specific actuarial mathematics techniques;
2 prepare, analyse and summarise raw data;
3 develop, systematically and creatively, actuarial models to solve actuarial problems;
4 apply, interpret and communicate the method, assumptions and results of the models derived in 3 above;
5 evaluate critically approaches to financial modelling and documentation.

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

1 exercise initiative and decision making in complex and unpredictable situations, using a logical mathematical approach to solving problems;
2 communicate effectively, both orally and in writing, at a level appropriate to the audience;
3 use appropriate information technology;
4 work effectively, both independently and in groups, planning and implementing tasks at a professional level.

Method of Assessment

100% coursework

Preliminary Reading

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

Synopsis *

The curriculum is intended to be consistent with that of the Institute and Faculty of Actuaries professional subject CP2.

Students will be given training to use Microsoft Word, Excel and PowerPoint to a level that is needed for the module (some familiarity with the packages is assumed).

The curriculum provides an introduction to, and development of, practical modelling techniques including the need for appropriate documentation, with a series of exercises to develop skills in applying techniques. Exercises are completed and discussed in class, along with the methods and principles of financial modelling and documentation.

MA953 Communications

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	15 (7.5)	50% Coursework, 50% Exam	

Contact Hours

Total contact hours: 36
Private study hours: 114
Total study hours: 150

Learning Outcomes

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

1 Draft communications relating to actuarial technical material intended to be read by a non-actuary, or by a specified person with technical actuarial skills, 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

2 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 successfully completing the module students will be able to:

1 demonstrate skills in the manipulation of actuarial material and an ability for logical argument.
2 demonstrate skills in organising information clearly, responding to written sources, presenting information orally and adapting style for different audiences;
3 demonstrate 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

This is primarily a practical module. The majority of the reading will be provided by specific lecture notes, but students should familiarise themselves with relevant financial publications such as the Financial Times, the Economist etc.

Synopsis *

Actuaries deal with complex concepts in multi-disciplinary teams, so it is vital that they can communicate 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 include group exercises.

MA960 Dissertation

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

Contact Hours

Total contact hours: 10
Private study hours: 590
Total study hours: 600

Learning Outcomes

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

1 demonstrate an awareness of the width, depth and wider relevance of an advanced mathematical topic of current interest,
2 carefully consider detailed, rigorous mathematical argument, whether within the context of an established mathematical theory or a substantive application of a mathematical theory,
3 express logical, coherent mathematical thought in an extended piece of work,
4 demonstrate high level technical writing and oral communication skills developed from the Communication in Mathematics module, as well as consolidated 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 plan, implement and complete an extended piece of work to professional level,
3 demonstrate initiative in the development of a line of research, argument and exposition,
4 demonstrate an ability to formulate detailed rigorous argument,
5 communicate in writing the width and depth of their understanding of a substantive body of knowledge,
6 speak on an advanced topic and answer questions on it,
7 apply basic research methods such as writing a literature survey including appropriate selection of materials and their critical evaluation.

Method of Assessment

100% project

Preliminary Reading

Texts depend on the individual dissertation topics.

Pre-requisites

Pre-requisite: MAST7703 Communicating Mathematics

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.

MA962 Geometric Integration

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Whole Year	M	15 (7.5)	70% Exam, 15% Coursework, 15% Project	

Contact Hours

Total contact hours: 30
Private study hours: 120
Total study hours: 150

Learning Outcomes

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

1 derive numerical methods and their properties;
2 demonstrate appreciation of the geometric interpretation of differential equations and numerical algorithms;
3 demonstrate understanding of the meaning and interpretation of error in approximations, in particular the relative importance of local errors versus global properties;
4 demonstrate appreciation of the importance, meaning and interpretation of numerical stability;
5 apply specific sophisticated numerical tools which preserve certain mathematical structures;
6 use mathematical software such as MatLab to masters level.

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

1 reason and deduce confidently from given definitions and constructions;
2 show an enhanced understanding of what is meant by an answer to a modelling problem;
3 read independently and manage their time;
4 demonstrate enhanced skills with mathematical and graphical software, to postgraduate level;
5 show their matured problem formulating and solving skills;
6 apply 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	Whole Year	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	

Contact Hours

Total contact hours: 32
Private study hours: 118
Total study hours: 150

Learning Outcomes

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

1 understand the basic concepts of topology with particular emphasis on CW complexes, manifolds and simplicial complexes;
2 apply topological methods to real-world problems;
3 use homological and computational methods to solve topological problems;
4 demonstrate geometric and algebraic intuition;
5 demonstrate the ability to formulate and prove abstract mathematical statements, and appreciate their connection with concrete calculation;
6 demonstrate enhanced computational skills.

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

1 communicate their own ideas clearly and coherently;
2 read and comprehend sophisticated mathematical ideas;
3 apply problem solving skills;
4 demonstrate an understanding of abstract concepts;
5 demonstrate their grasp of a wide variety of mathematical techniques and methods.

Method of Assessment

70% Examination, 15% Coursework, 15% Project

Preliminary Reading

Introduction to Metric & Topological Spaces, W A Sutherland, 2nd edition, Oxford UP, 2009.
Basic Topology, M A Armstrong, Springer, 1983.
A Basic Course in Algebraic Topology, W S Massey, Springer, 1991.
Computational Homology, Kaczynski, Mischaikow & Mrozek, Springer, 2004.
Introduction to Topology: Pure and Applied, C Adams & R Franzosa, Pearson/Prentice Hall, 2008.
Algebaric Topology, A Hatcher, Cambridge UP, 2012.

Pre-requisites

MAST5670 (Topology) or equivalent

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.

MA965 Symmetries, Groups and Invariants

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	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 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	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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

There is no essential reading or core text. Background reading for level 6 and 7 students:

F W Byron, "Mathematics of classical and quantum physics", Addison-Wesley, (1970)
A Durrant, "Quantum Physics of Matter", Institute of Physics (2000)
J Manners, "Quantum Physics: An introduction", Institute of Physics (2000)
A I M Rae, "Quantum Physics: A Beginner's Guide", Oneworld Publications (2005)
R Shankar, "Principles of quantum mechanics", Plenum Press (1994)
J J Sakurai, "Modern quantum mechanics", Addison-Wesley (1994)

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.
Indicative syllabus for the joint level 6/level 7 curriculum:
• The necessity for quantum mechanics. The wavefunction and Born's probabilistic interpretation.
• Solutions of the time-dependent and time-independent Schrödinger equation for a selection of simple potentials in one dimension.
• Reflection and transmission of particles incident onto a potential barrier. Probability flux. Tunnelling of particles.
• Wavefunctions and states, Hermitian operators, outcomes and collapse of the wavefunction.
• Heisenberg's uncertainty principle.
Additional topics may include applications of quantum theory to physical systems, quantum computing or recent developments in the quantum world.
Level 7 students will also study:
The three-dimensional Schrödinger equation with a central potential, spherical harmonics, angular-momentum and the hydrogen atom.

MA968		Mathematics and Music				
Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
3	Canterbury	Spring	M	15 (7.5)	70% Exam, 15% Coursework, 15% Project	

Contact Hours

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 discrete Fourier analysis, the geometry of world rhythms and rhythmic tilings, and the geometry of harmony space;
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: Chladni patterns, digital signal processing, the mathematical construction of world rhythms;
3 apply a range of concepts and principles in discrete Fourier analysis 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 and musical composition software as appropriate.

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

D. Benson, Music: A Mathematical Offering Cambridge University Press, Cambridge, 2006.
G. Loy, Musimathics: The Mathematical Foundations of Music MIT Press, Vols 1 and 2, 2007.
N. Collins, Introduction to Computer Music, Wiley, 2010.
J.S. Walker and G.W. Don, Mathematics and Music: Composition, perception and performance, CRC Press, 2013
D. Tymoczko, A Geometry of Music, Oxford University Press, 2011.
G. Toussaint, The Geometry of Musical Rhythm, CRC Press, 2013.

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. 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 prerequisite.
Indicative syllabus:
Part 1
a. The mathematics of the drum
i. Solutions of the linear wave equation in two dimensions in terms of Bessel functions
ii. Standing waves and Chladni patterns

b. The mathematics of digital music processing
i. Aliasing, Sampling, Filtering
ii. Discrete Fourier Transform, Convolutions
iii. Gabor transform and applications
iv. Spectrograms and applications

Part 2
c. The mathematics of rhythm: Euclidean rhythms in world music
i. The mathematics of harmony in tonal music: Introduction to a mathematical chord space, the Tonnetz.

At level 7, topics will be studied and assessed to greater depth.

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.

MA971 Introduction to Functional Analysis

Version	Campus	Term(s)	Level	Credit (ECTS)	Assessment	Convenor
2	Canterbury	Spring	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:
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	Whole Year	M	15 (7.5)	70% Exam, 30% Coursework	

Contact Hours

30 hours

Learning Outcomes

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

1 rigorous thinking.
2 calculating with and visualization of geometrical objects.
3 systematic observation, generalization and techniques of proof.
4 the use of geometrical methods in other areas of mathematics and physics.
5 algebraic and analytical techniques for understanding geometry.
6 classification of objects according to their topological and geometrical properties.
7 connecting abstract mathematics to the real world.
8 proficient use of mathematical software such as Maple and MAGMA to masters level.

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

1 an enhanced ability to correctly formulate geometrical problems and solve them efficiently;
2 enhanced skills in understanding and communicating mathematical results and conclusions;
3 a holistic view of mathematics as a problem solving and intellectually stimulating discipline;
4 an appreciation of algorithms and computational methods in geometry.
5 matured in their problem formulating and solving skills;
6 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

Complex Algebraic Curves, Frances Kirwan, LMS Student Texts 23, Cambridge, 1992, ISBN-100521423538.
Algebraic Curves and Riemann Surfaces, Rick Miranda, Graduate Studies in Math., vol. 5, AMS, 1995, ISBN 0-8218-0268-2.
Lectures on elliptic curves. J.W.S. Cassels, LMS Student Texts 24, Cambridge, 1991, ISBN-100521425301.
Algebraic Aspects of Cryptography, N. Koblitz, Springer, 1998, ISBN 978-3-540-63446-1.
A Course of Modern Analysis, E.T. Whittaker and G.N. Watson, Cambridge, fourth edition, 1927 (reprinted 2005), ISBN 0-521-58807-3.
The Arithmetic of Elliptic Curves, Joseph H. Silverman, Graduate Texts in Mathematics 106, Springer, 1986, ISBN 0-387-96203-4.

Pre-requisites

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.

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

Total contact hours: 8
Private study hours: 292
Total study hours: 300

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.

Pre-requisites

MAST7703 Communicating Mathematics

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
2	Canterbury	Whole Year	M	30 (15)	100% Coursework	
1	Canterbury	Spring	M	30 (15)	95% Project, 5% Coursework	

Contact Hours

Total contact hours: 12
Private study hours: 288
Total study hours: 300

Learning Outcomes

The intended subject specific learning outcomes.
On successfully completing the module students:
1. demonstrate awareness of the relationship of the material to background material and to more advanced material;
2. write a coherent account of an area of Statistics, with particular reference to applications in Finance, if appropriate;
3. perform statistical analyses that show the depth of student understanding of the statistical methods relevant to the topic;
4. present complex analyses and draw appropriate conclusions with clarity and accuracy;
5. demonstrate understanding of theoretical and practical aspects of analysing statistical data;
6. Use the text-processing software LaTeX to prepare presentation slides and to present their dissertation.

The intended generic learning outcomes.
On successfully completing the module students:
1. apply a logical, mathematical approach to solving complex problems, at an advanced level;
2. work with relatively little guidance, and be able to exercise initiative;
3. utilise advanced organisational, computer and study skills, and be able to adapt them to new situations;
4. produce a dissertation that effectively communicates the material to the reader;
5. demonstrate an ability to evaluate research work critically;
6. select appropriate material from complex source texts, either recommended to or found by the student.

Method of Assessment

Assessment: By presentation (20%), coursework (10%) and dissertation (70%).

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.

Pre-requisites

None

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	Whole Year	M	30 (15)	100% Coursework	

Contact Hours

Total contact hours: 10
Placement at employer and private study hours: 290
Total study hours: 300

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 14-15 pages in length – 50% of total module mark;
• Poster & Presentation with questions of around 15-20 minutes – 50 % of total module mark.

Pre-requisites

Co-requisite: MAST7805 Industrial Placement Experience

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 under MAST7805 (Industrial Placement Experience) which is a co-requisite of this module. The assessment of this module draws on the experience gained in MAST7805 and is assessed through a Placement Report and Presentation.
The placement 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 this module.
Participation in the placement year, and hence 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 satisfactory achievement in their academic studies.

MA977 Industrial Placement Experience

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

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	Whole Year	M	60 (30)	Pass/Fail Only	

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	Whole Year	M	90 (45)	Pass/Fail Only	

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	Whole Year	M	120 (60)	Pass/Fail Only	

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	Spring	M	15 (7.5)	80% Exam, 20% Coursework	
2	Canterbury	Autumn	M	15 (7.5)	80% Exam, 20% Coursework	

Contact Hours

Total contact hours: 42
Private study hours: 108
Total study hours: 150

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 Graphs and Combinatorics;
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: trees, shortest
paths problems, walks on graphs, graph colourings and embeddings, flows and matchings, matrices and graphs;
3 apply a range of concepts and principles in Graphs and Combinatorics theory 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

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.

Pre-requisites

Students are expected to have studied material equivalent to that covered in the following modules:
MAST4001 (Algebraic Methods) or MAST4005 (Linear Mathematics)

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 for level 7 students, the module will cover an advanced topic in combinatorics such as: problems in extremal set theory; enumerative problems; Principle of Inclusion and Exclusion; Ramsey theory; computational complexity; the P versus NP problem.