MTH6100 Actuarial Mathematics

Description

This module gives an introduction to the mathematics of life assurance. You will learn to value cash flows and use life tables for making predictions and analysing mortality patterns. This leads on to the valuation of life annuities and of the benefits paid in life assurance policies. Various life assurance products will be explained and then used for illustration of the basic principles of life assurance.

Details

Organiser: Dr R J Harris

Level: 6  Credit value: 15  Semester: B

Overlaps:
- MAS224 Actuarial Mathematics

Essential prerequisites:
- MTH4101 Calculus II

and either of
- MTH4107 Introduction to Probability
- MTH4108 Probability I

Helpful prerequisites:

Any of
- MTH5118 Probability II
- MTH5121 Probability Models
- MTH5122 Statistical Methods

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~harris/MTH6100

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus

1. Compound interest: discounting, force of interest, nominal values (APR); annuities certain: accumulated amount; schedule of principal and interest; perpetuities.
2. Life tables (LT): LT functions; the LT as model of cohort experience or stationary distribution; survival probabilities in terms of LTs. Reference to actual populations: tables of annuitants and assured lives. Select LTs.
3. Valuation: monetary functions; values of endowments, annuities and assurances.
4. Calculation of premiums; policy and surrender values; paid up policies.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6100

Learning resources

Recommended:
- McCutcheon & Scott, An Introduction to the Mathematics of Finance (Heinemann)
- A Neill, Life Contingencies (Heinemann)
- Bowers, Gerber, Hickman et al., Actuarial Mathematics (SoA)

MTH742U Advanced Combinatorics

Description

This module builds on the combinatorial ideas of the modules Combinatorics and Extremal Combinatorics and introduces some of the more advanced tools for solving combinatorial and graph theoretic problems. The topics covered will depend on the module organiser's expertise but significant emphasis will be on the techniques used as well as the results proved.
Details

Organiser: Professor T Müller

Level: 7  Credit value: 15  Semester: B

Overlaps:
- MTH710U Enumerative and Asymptotic Combinatorics
- MTHM042 Enumerative and Asymptotic Combinatorics
- MTH738U Additive Combinatorics
- MTH738P Additive Combinatorics

Essential prerequisites:
- MTH6109 Combinatorics

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~twm/MTH742U

Comment: New module in 2011–12 to replace "Enumerative Combinatorics" and "Additive Combinatorics".

Syllabus

This module aims to introduce students to some of the more advanced techniques used in combinatorics such as the Regularity Lemma, probabilistic techniques, the discrete Fourier transform, eigenvalue methods and generating functions with the intention that the students will be able to recognise and then apply the appropriate tools in unfamiliar situations.

Learning outcomes

- Knowledge and understanding of:
  - Advanced combinatorial techniques, such as probabilistic techniques, the discrete Fourier transform, eigenvalue methods and generating functions
  - Ideas used in more advanced combinatorics, such as asymptotic or additive techniques

- Intellectual skills – able to:
  - Decide which techniques are appropriate for specific combinatorial problems
  - Apply these techniques for solving these problems

- Transferable skills – able to:
  - Explain clearly which techniques are useful for solving advanced combinatorial problems
  - Read technical papers on advanced combinatorics and summarise them

Learning resources

Main texts:
- P. J. Cameron, Enumerative and Asymptotic Combinatorics, Lecture notes.

MTH703U Advanced Cosmology

Description

Cosmology is a rapidly developing subject that is the focus of a considerable research effort worldwide. It is the attempt to understand the present state of the universe as a whole and thereby shed light on its origin and ultimate fate. Why is the universe structured today in the way that it is, how did it develop into its current form and what will happen to it in the future? The aim of this course is to address these and related questions from both the observational and theoretical perspectives. The course does not require specialist astronomical knowledge and does not assume any prior understanding of general relativity.

Details

Organiser: Dr A G Polnarev

Level: 7  Credit value: 15  Semester: A

Overlaps:
- MAS401 Advanced Cosmology
Essential prerequisites:
- MTH5106 Dynamics of Physical Systems

Assessment:
- 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~agp/MTH703U

Syllabus
1. Observational basis for cosmological theories. Derivation of Friedmann models and their properties.
2. Cosmological tests: source counts; flux-redshift and luminosity-volume diagrams; integrated background radiation; evolution.
3. Observational cosmology: the distance scale and the Hubble constant; the age of the Universe; the density parameter.
4. Physics of the Big Bang: cosmological nucleo-synthesis; the cosmic microwave background radiation (CMBR); the decoupling era; large and small scale anisotropy in the CMBR; galaxy formation: the growth of fluctuations; effect of hot and cold dark matter; viable galaxy formation scenarios.
5. The very early Universe: phase transitions; inflation; cosmic strings.
6. The intergalactic medium: evidence from X-ray and microwave backgrounds, absorption-line systems in quasar spectra; Gunn-Peterson effect; role of dust in pre-galactic era; the Sunyaev-Zel'dovich effect.

Learning outcomes
Not yet available

MTH5100 Algebraic Structures I

Description
The modern axiomatic approach to mathematics is demonstrated in the study of algebraic structures. Elementary group theory includes the study of subgroups and Lagrange's theorem. Ring theory includes integral domains, ideals, homomorphisms and isomorphism theorems, polynomial rings, the Euclidean algorithm, and fields of fractions. This module has been revised for 2011–12 to focus more on ring theory, featuring familiar examples. Group theory will now mostly be covered by the follow-on module Algebraic Structures II.

Details
Organiser: Professor L H Soicher
Level: 5  Credit value: 15  Semester: B

Overlaps:
- MAS201 Algebraic Structures I

Essential prerequisites:
- MTH4104 Introduction to Algebra

Assessment:
- 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~leonard/MTH5100

Comment: Assessment in 2010–11 was 20% in-term test, 80% final exam

Syllabus
1. Revision of sets, functions, operations, relations, equivalence relations.

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5100

Learning resources
Reading list:
- P J Cameron, Introduction to Algebra (Oxford)
MTH6104 Algebraic Structures II

Description

This is a second module in algebraic structures, covering group theory. There will be abstract thinking and proofs but also an emphasis on examples. The module includes the basics of group actions, finite $p$-groups, Sylow theorems and their applications, and the Jordan-Hölder theorem. The module has been revised for 2011–12 in order to make it more accessible by focussing on group theory although some of the ideas in the group theory are parallel to those first encountered in the earlier module on rings and numbers.

Details

Organiser: Dr M Fayers

Level: 6  Credit value: 15  Semester: A

Overlaps:
- MAS305 Algebraic Structures II

Essential prerequisites:
- MTH5100 Algebraic Structures I

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~mf/MTH6104

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus

1. Group homomorphisms, isomorphisms, automorphisms. Conjugacy and normal subgroups; examples.
2. Construction of factor groups, 1st, 2nd and 3rd isomorphism theorems for groups; examples.
3. Group actions; finite $p$-groups; Sylow theorems and applications.
4. Jordan-Hölder theorem; finite soluble groups; examples.

Learning outcomes

By the end of the module, students will be able to:
- define groups, orders, subgroups, conjugacy, normal subgroups, quotient groups;
- define, manipulate and understand basic properties of important examples (including cyclic, dihedral, symmetric and alternating groups);
- state and prove the Isomorphism Theorems and the Correspondence Theorem;
- define group actions, describe important examples and prove the Orbit-Stabiliser Theorem and the Orbit-Counting Lemma;
- state and prove Sylow's Theorems and use them to study the structure of small groups;
- define simple groups, and prove that the alternating groups are simple;
- define composition series and state and prove the Jordan-Hölder Theorem;
- define soluble groups and understand basic properties.

Learning resources

Main text:
- P J Cameron, Introduction to Algebra (OUP)

Other text:
- W Ledermann and A J Weir, Introduction to Group Theory, second edition (Longman)

MTH6105 Algorithmic Graph Theory

Description

This module uses an algorithmic approach to introduce basic concepts and results on graphs and networks. It also shows how fundamental optimisation problems on graphs and networks, such as finding shortest paths or maximum flows, can be solved efficiently.

Details

Organiser: Professor R Whitty

Level: 6  Credit value: 15  Semester: B
Overlaps:
- MAS210 Graph Theory and Applications
- MAS236 Algorithmic Graph Theory

Helpful prerequisites:

Any of
- MTH4104 Introduction to Algebra
- MTH4107 Introduction to Probability
- MTH4108 Probability I

Assessment: 100% final exam

Organiser's module website: [http://www.maths.qmul.ac.uk/~whitty/MTH6105](http://www.maths.qmul.ac.uk/~whitty/MTH6105)

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus

2. Applications of trees: finding connected components, depth and breadth first search, minimum weight spanning trees, shortest path spanning trees, longest path spanning trees in acyclic directed networks.
4. Maximum size and maximum weight matchings in bipartite graphs.
5. Euler tours in graphs and digraphs and the Chinese Postman Problem.

Learning outcomes

[http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6105](http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6105)

Learning resources

Main text:
- A printed detailed course summary will be available from the Bookshop and/or the web.

Other texts:
- Gibbons, Algorithmic Graph Theory, Cambridge University Press
- Wilson and Watkins, Graphs, An Introductory Approach, Wiley

MTH705U Applied Statistics

Description

The semester will be divided into three four-week periods. In each a genuine application of statistics will be studied, led by a different lecturer with at most two lectures per period. The list of topics will vary from year to year and you should obtain the current list from the module organiser.

Details

Organiser: Dr H Grossmann

Level: 7  Credit value: 15  Semester: B

Overlaps:
- MAS421 Applied Statistics

Essential prerequisites:
- MTH5120 Statistical Modelling I

Helpful prerequisites:
- MTH6116 Design of Experiments
- MTH6134 Statistical Modelling II
- MTH6139 Time Series

**Assessment:** 3 reports (about 10–15 pages each, on separate topics), 33% each

**Organiser's module website:** [http://www.maths.qmul.ac.uk/~hg/MTH705U](http://www.maths.qmul.ac.uk/~hg/MTH705U)

**Comment:** Was Semester A in 2010–11

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**Syllabus**

The semester will be divided into three four-week ‘months’. In each month there is a genuine piece of applied statistics, led by a different lecturer. The lecturer will set it up with at most 2 lectures. At the end of the month the student will hand in a report of 10–15 pages. Statistical techniques and statistical computing packages from previous statistics modules will be needed. The three topics will be chosen from the following list:

1. Design of experiments
2. Medical statistics
3. Time series analysis of spacecraft data
4. Multivariate data from crop research
5. Agricultural statistics
6. Economic statistics
7. Industrial statistics

See module organiser before registering.

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**Learning outcomes**

Not yet available

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**MTH708U Astrophysical Plasmas**

**Description**

A plasma is an ionized gas where the magnetic and electric field play a key role in binding the material together. Plasmas are present in almost every astrophysical environment, from the surface of pulsars to the Earth's ionosphere. This course explores the unique properties of plasmas, such as particle gyration and magnetic reconnection. The emphasis is on the plasmas found in the Solar System, from the solar corona and solar wind to the outer reaches of the heliosphere and the interstellar medium. Fundamental astrophysical processes are explored, such as the formation of supersonic winds, magnetic energy release, shock waves and particle acceleration. The course highlights the links between the plasmas we can observe with spacecraft and the plasmas in more distant and extreme astrophysical objects.

**Details**

**Organiser:** Professor D H Burgess

**Level:** 7  
**Credit value:** 15  
**Semester:** A

**Overlaps:**

- MAS429 Astrophysical Plasmas

**Prerequisites:** Appropriate level-6 mathematical background; consult the module organiser for details

**Assessment:** 100% final exam

**Organiser's module website:** [http://www.maths.qmul.ac.uk/~dhb/MTH708U](http://www.maths.qmul.ac.uk/~dhb/MTH708U)

**Comment:** Not offered 2010–11

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**Syllabus**

A plasma is an ionized gas where the magnetic and electric field play a key role in binding the material together. Plasmas are present in almost every astrophysical environment, from the surface of pulsars to the Earth's ionosphere. This course explores the unique properties of plasmas, such as particle gyration and magnetic reconnection. The emphasis is on the plasmas found in the Solar System, from the solar corona and solar wind to the outer reaches of the heliosphere and the interstellar medium. Fundamental astrophysical processes are explored, such as the formation of supersonic winds, magnetic energy release, shock waves and particle acceleration. The course highlights the links between the plasmas we can observe with spacecraft and the plasmas in more distant and extreme astrophysical objects.

**Learning outcomes**

Not yet available

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**MTH709U Bayesian Statistics**
Description

The module aims to introduce you to the Bayesian paradigm. The module will show you some of the problems with frequentist statistical methods, show you that the Bayesian paradigm provides a unified approach to problems of statistical inference and prediction, enable you to make Bayesian inferences in a variety of problems, and illustrate the use of Bayesian methods in real-life examples.

Details

Organiser: Dr L Pettit

Level: 7  Credit value: 15  Semester: B

Overlaps:

- MAS442 Bayesian Statistics

Essential prerequisites:

Either of

- MTH6136 Statistical Theory
- MTH736U Mathematical Statistics

Helpful prerequisites:

- MTH5120 Statistical Modelling I

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~pettit/MTH709U

Syllabus

1. The Bayesian paradigm – likelihood principle, sufficiency and the exponential family, conjugate priors, examples of prior to posterior analysis, mixtures of conjugate priors, non-informative priors, two sample problems, predictive distributions, constraints on parameters, point and interval estimation, hypothesis tests, nuisance parameters.

2. Linear models – use of non-informative priors, normal priors, two and three stage hierarchical models, examples of one way model, exchangeability between regressions, growth curves, outliers and influential observations.


4. Examples – appropriate examples will be discussed throughout the course. Possibilities include epidemiological data, randomised clinical trials, radiocarbon dating.

Learning outcomes

On completion of this course students should: Appreciate the differences between the Bayesian paradigm and frequentist statistical methods; Be able to calculate posterior and predictive distributions and related quantities for a range of likelihoods and priors; Be familiar with the ideas of Gibbs sampling as an example of a Markov chain Monte Carlo method and be able to set up models in this framework; Understand the arguments for and against the Bayesian paradigm.

Learning resources

Main text:

- Lee P M, Bayesian Statistics: An Introduction, (3rd Ed) Edward Arnold

MTH4100 Calculus I

Description

This is the first of three calculus modules, whose collective aim is to provide the basic techniques and background from calculus for the pure, applied and applicable mathematics modules that follow. This module develops the concepts and techniques of differentiating and integrating, with supporting work on algebra, coordinate transformations and curve sketching.

Details

Organiser: Dr K Malik

Level: 4  Credit value: 15  Semester: A

Overlaps:

- Modules 2011–12 | School of Mathematical Sciences http://www.maths.qmul.ac.uk/~fjw/modules/modules.html
MAS115 Calculus I
ECN114 Math. Methods in Economics and Business I
PHY121 Mathematical Techniques I

Prerequisites: A-Level Mathematics or equivalent

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~malik/MTH4100

Comment: Assessment in 2010–11 was 20% in-term test, 80% final exam

Syllabus


3. Limits. Calculating limits using the Limit Laws and by eliminating zero denominators algebraically. The precise definition of a limit, finding deltas algebraically for given epsilons. One-sided limits and limits at infinity. Limits involving sin \( \frac{x}{x} \). Limits at infinity of rational functions, horizontal and oblique asymptotes. Infinite limits and vertical asymptotes. Continuous functions. Intermediate Value Theorem for continuous functions (without proof) and its applications.


6. Derivatives III. Indeterminate forms (0/0, \( \frac{\infty}{\infty} \), \( \infty - \infty \)) of limits and l'Hopital's Rule. Limits involving \((1 + \frac{1}{x})^x\). Logarithmic, power and exponential rates of growth. Implicit differentiation. Tangent and normal to a curve defined by \( f(x,y) = 0 \) or parametrically. Derivatives of inverse functions. Inverse trigonometric functions (graphs, derivatives). First look at hyperbolic functions (algebra of, inverse functions, derivatives, graphs).

7. Integration I. Indefinite integral as anti-derivative. Techniques for evaluating indefinite integrals. Integration by substitution and integration by parts as the reverse processes of the chain rule and product rules. [Non-examinable reading assignment for any student not taking MTH4102 Differential Equations in the second semester: first order separable differential equations; first order linear differential equations by the method of integrating factor.]


Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4100

Learning resources

Main text:

- Calculus I and II follow Thomas' Calculus and make use of an interactive maths web site MyMathLab, which is tied to the book. Buying this book in advance is not advisable. The book and access code for MyMathLab will be available at a discounted price in September from the QM bookshop.
MAS125 Calculus II
ECN114 Math. Methods in Economics and Business I
PHY121 Mathematical Techniques 1
PHY122 Mathematical Techniques 2

Essential prerequisites:
- MTH4100 Calculus I

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~klages/MTH4101

Comment: Assessment in 2010–11 was 20% in-term test, 80% final exam

Syllabus

1. Complex numbers I: definition and their necessity for elementary operations, geometric representation, loci and regions in the complex plane, quadratic equations with real coefficients.
2. Complex numbers II: Euler's relation, DeMoivre's Theorem and applications to trigonometric identities, square root and log functions. Application to integrals ∫ e^{ax} \cos(bx) \, dx.
5. Integration III. Double integrals as volumes under surfaces and areas in the plane. Properties of double integrals. Double integrals as repeated integrals, rectangular regions, simple non-rectangular regions.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4101

Learning resources

Main text:
- Calculus I and II follow Thomas' Calculus and make use of an interactive maths web site MyMathLab, which is tied to the book. Buying this book in advance is not advisable. The book and access code for MyMathLab will be available at a discounted price in September from the QM bookshop.

MTH5102 Calculus III

Description

The module develops the elements of vector calculus and advanced topics in ordinary and partial differential equations, such as special functions, Fourier series and Laplace's equation, for application in subsequent applied mathematics modules.

Details

Organiser: Dr W J Sutherland

Level: 5  Credit value: 15  Semester: A

Overlaps:
- MAS204 Calculus III
- PHY122 Mathematical Techniques 2
Essential prerequisites:

- MTH4101 Calculus II

and

- MTH4103 Geometry I

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: [http://www.maths.qmul.ac.uk/~wjs/MTH5102](http://www.maths.qmul.ac.uk/~wjs/MTH5102)

Comment: Assessment in 2010–11 was 10% coursework, 10% in-term test, 80% final exam

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**Syllabus**

1. Arc-length of plane curves: length of a parametric curve, length of a curve \( y = f(x) \). Length of the circumference of a circle, ellipse. Area and length in polar coordinates.
2. Vector fields, line, surface and volume integrals.
4. Orthogonal curvilinear coordinates; length of line element; grad, div and curl in curvilinear coordinates; spherical and cylindrical polar coordinates as examples.
5. A first look at Legendre polynomials.

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**Learning outcomes**

[http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5102](http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5102)

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**Learning resources**

Main text:

- Thomas' Calculus, 11th Edition (Addison Wesley)

Other texts:

- M R Spiegel, Vector Analysis (Schaum Outline Series, McGraw-Hill)
- S Simons, Vector Analysis for Mathematicians, Scientists & Engineers (Pergamon Press)

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**MTH6107 Chaos and Fractals**

**Description**

The main aims are two fold: to illustrate (rigorously) how simple deterministic dynamical systems are capable of extremely complicated or chaotic behaviour; to make contact with real systems by considering a number of physically motivated examples and defining some of the tools employed to study chaotic systems in practice. Discrete and continuous dynamical systems, repellers and attractors, Cantor sets, symbolic dynamics, topological conjugacy for maps, definition of chaos. Fractals, iterated function systems, Julia sets.

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**Details**

Organiser: Professor F Vivaldi

Level: 6  Credit value: 15  Semester: A

Overlap:

- MAS308 Chaos and Fractals

Essential prerequisites:

- MTH4101 Calculus II

and

- MTH4103 Geometry I

Assessment: 100% final exam

Organiser's module website: [http://www.maths.qmul.ac.uk/~fv/MTH6107](http://www.maths.qmul.ac.uk/~fv/MTH6107)
Syllabus

1. Continuous-time and discrete-time dynamical systems, Poincaré surface of section.
3. The logistic map, period-doubling scenario, Feigenbaum constants and Feigenbaum-Cvitanovic equation, tangent bifurcation and intermittency.
4. Definition of chaos, Lyapunov exponents, Bernoulli shift, topological conjugacy, symbolic dynamics.
5. Invariant measures and invariant densities, Perron-Frobenius operator, time and ensemble average, ergodicity.
7. Examples of simple fractals, fractal dimension, Renyi dimensions.
8. Complex dynamics, Julia sets and Mandelbrot set, iterated function systems.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6107

Learning resources

Essential:
- Chaos and Fractals lecture notes, http://www.maths.qmul.ac.uk/~fv/teaching/chaos/LectureNotes.html

Recommended:
- R Devaney, An introduction to chaotic dynamical systems (Addison-Wesley)
- Beck/Schloegl, Thermodynamics of Chaotic Systems (CUP)
- D Gulick, Encounters with Chaos (McGraw Hill)

MTH6108 Coding Theory

Description

The theory of error-correcting codes uses concepts from algebra, number theory and probability to ensure accurate transmission of information through noisy communication links. Basic concepts of coding theory. Decoding and encoding. Finite fields and linear codes. Hamming codes. Parity checks. Preliminary algebra on vector spaces and finite fields will be included in the module.

Details

Organiser: Dr M Fayers
Level: 6  Credit value: 15  Semester: B

Overlaps:
- MAS309 Coding Theory

Essential prerequisites:
- MTH5112 Linear Algebra I

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~mf/MTH6108

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus

The concept of an error-correcting code is a very important one, with wide applications in communications. This module approaches the subject from a pure-mathematics perspective, to give the student a thorough grounding in construction of codes and decoding algorithms, and the main coding theory problem.

1. Basic concepts: codes, minimum distance, equivalence of codes.
2. The Main Coding Theory Problem. The Hamming, Singleton and Plotkin bounds.
4. Linear codes. Generator matrices and parity-check matrices. Syndrome decoding. (A very brief review of the required linear algebra will be given.)
5. Examples: Reed-Muller, Hamming, Golay and MDS codes.

Learning outcomes
MTH6109 Combinatorics

Description
Combinatorics involves reasoning about 'discrete' structures, particularly finite sets of objects where there are links or relationships among the objects. The module is largely concerned with concepts and theory, but this is a subject that has many practical applications. Counting, recurrence relations, permutations. Steiner triple systems: construction and properties. Ramsey's theorem and applications. Transversal theory.

Details
Organiser: Professor R A Wilson
Level: 6  Credit value: 15  Semester: A
Overlaps:
- MAS219 Combinatorics
Essential prerequisites:
- MTH5112 Linear Algebra I
Helpful prerequisites:
Either of
- MTH4107 Introduction to Probability
- MTH4108 Probability I
Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~raw/MTH6109
Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus
1. Counting, binomial coefficients, recurrence relations, generating functions, partitions and permutations, finite fields, Gaussian coefficients.
2. Steiner triple systems, necessary conditions, direct and recursive constructions, structural properties and characterisations.
3. Ramsey's theorem, illustrations, proof and applications.
4. Transversal theory, Latin squares, Hall's theorem, upper and lower bounds.

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6109

Learning resources
Main text:
- P J Cameron, Combinatorics (CUP)

Other texts:
- J H Van Lint, R M Wilson, A Course in Combinatorics (CUP)
- I Anderson, A First Course in Combinatorial Mathematics (OUP)
- N L Biggs, Discrete Mathematics, Oxford Science Publication (OUP)
This module allows undergraduates to gain valuable transferable skills whilst exploring the teaching profession first hand by working with a teacher in a local school. The key skills gained include communication and presentation of mathematics, team-working, active listening, time management and prioritisation. The module will be supported by regular classes and assessed by a combination of written reports and an oral presentation. Registration for this module requires validation; places will be limited and interviews to assess suitability will be held during Semester A.

Details

Organiser: Dr C Agnor / Dr D Ellis

Level: 6  Credit value: 15  Semester: B

Overlaps: None

Essential prerequisites:

- Acceptance based on academic record and an interview in Semester A; consult the module organiser for details.

Restrictions: Restricted to Queen Mary Mathematical Sciences students.

Assessment: Journal of teaching activity (2,500 words) 30%; end-of-module report on "special project" (2,500 words) 30%; end-of-module presentation on "special project" (10 minutes plus 5 minutes discussion) 20%; teacher's end-of-module report 20%

Organiser's module website: http://www.maths.qmul.ac.uk/~agnor/MTH6110

Syllabus

Students will typically begin by observing the teacher's handling of the class and progress from this classroom assistant stage through small teaching tasks to at least one opportunity to undertake whole class teaching, possibly for a short part of a lesson. They will represent and promote mathematics as a potential university choice.

Students will undertake and evaluate a special project on the basis of discussion with the teacher. This may involve a specific in-class teaching problem or an extra-curricular project such as a lunchtime club or special coaching periods for higher ability pupils. The student will keep a journal of their own progress in working in the classroom environment, and they will be asked to submit a reflective written report on the special project and other relevant aspects of the school placement experience. This format is standard within the Undergraduate Ambassadors Scheme (http://www.uas.ac.uk/).

1. Initial day of training.
2. Competitive interview system to ensure students' suitability for the module.
3. Student will be matched with an appropriate school and a specific teacher in the local area.
4. Student will spend the equivalent of half a day a week in the school every week for a semester.
5. No formal lectures.
6. A supporting tutorial for one hour once a week for students to share experiences.
7. Teachers will act as the main source of guidance but students will also be able to discuss their progress with the module organiser and the More Maths Grads team as needed.
8. End of unit presentation of special project (15 minutes per student)

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6110

Learning resources

You should consult:

- The National Curriculum website: http://www.nc.uk.net/home.html
- The Teacher Training Agency website: http://www.canteach.gov.uk
- The National Centre for Excellence in the Teaching of Mathematics: http://www.ncetm.org.uk
- Improving Learning in Mathematics: challenges and strategies, Malcolm Swan, which can be downloaded from http://www.maths4life.org/content.asp?CategoryID=1068

MTH6111 Complex Analysis

Description

This is a rigorous module in complex analysis. The first part of the course will be concerned with detailed analysis of topics already seen in Complex Variables, such as differentiation, integration, Taylor and Laurent series, conformal mappings and the residue theorem. The second part of the course will introduce more advanced topics, perhaps including Riemann surfaces and elliptic functions.
Details

Organiser: Professor C-H Chu

Level: 6  Credit value: 15  Semester: B

Overlaps:
- MAS310 Complex Functions

Essential prerequisites:
- MTH5103 Complex Variables

and
- MTH5104 Convergence and Continuity

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~cchu/MTH6111

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus

A rigorous module in complex analysis. The first part of the module will be concerned with detailed analysis of topics already seen in Complex Variables:

1. Differentiation and integration
2. Cauchy's theorem, Taylor and Laurent series
3. Conformal mappings and harmonic functions
4. The residue theorem and the calculus of residues

The second part of the module will introduce more advanced topics, e.g. some or all of

1. Riemann surfaces
2. Complex gamma, beta and zeta functions
3. Elliptic functions
4. Picard's theorem

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6111

Learning resources

Consult module organiser before buying any book specifically for this module since we shall be using a number of texts. Possibilities include

- I N Stewart & D O Tall, Complex Analysis (CUP)
- H A Priestley, Introduction to Complex Analysis (OUP)

MTH743U Complex Systems

Description

Complex systems can be defined as systems involving many coupled units whose collective behaviour is more than the sum of the behaviour of each unit. Examples of such systems include coupled dynamical systems, fluids, transport or biological networks, interacting particle systems, etc.

The aim of this module is to introduce students with a number of mathematical tools and models used to study complex systems and to explain the mathematical meaning of key concepts of complexity science, such as self-similarity, emergence, and self-organisation. The exact topics covered will depend on the module organiser's expertise with a view to cover practical applications using analytical and numerical tools drawn from other applied modules.

Details

Organiser: Dr W Just

Level: 7  Credit value: 15  Semester: B

Overlaps: None

Prerequisites: Appropriate level-6 mathematical background; consult the module organiser for details

Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~wj/MTH743U

Comment: New module in 2011–12, partly to replace Fluid Dynamics

Syllabus

1. Introduction to the field of complex systems via a number of representative examples and models of these systems (e.g., coupled dynamical systems, time-delayed systems, stochastic processes, networks, time series, fractals, multifractals, particle models)
2. Introduction to basic tools and quantities used in the study of complex systems (e.g., bifurcation diagram, symbolic dynamics, dimensions, Lyapunov exponents, complexity measures, entropies)
3. Introduction to the concepts of emergence and self-organisation in the context of basic models of complex models
4. Introduction to basic computational and numerical methods used to study complex systems

Learning outcomes

- Knowledge and understanding of:
  - Basic concepts used in the modelling of complex systems (e.g., coupled dynamical systems, maps, stochastic processes, particle models, networks, chaotic motion, fractals, multifractals, fluids)
  - Basic tools used to study complex systems (e.g., bifurcation diagram, symbolic coding, Lyapunov exponents, entropies, complexity measures, centrality measures)
  - Certain phenomena associated with complex systems: e.g., chaos, ergodicity, self-similarity, scaling, emergence, self-organisation
- Intellectual skills – able to:
  - Construct and understand simple models of complex systems (e.g., coupled maps, coupled or delayed differential equations, particle models, networks)
  - Use different tools to study the properties or behaviour of certain complex systems
  - Distinguish different properties or behaviours of complex systems (e.g., regular motion, chaotic motion, synchronisation, turbulence)
- Transferable skills – able to:
  - Construct short programs to simulate simple models of complex systems numerically
  - Read technical papers on complex systems and summarise them

Learning resources

Main texts:

MTH5103 Complex Variables

Description


Details

Organiser: Professor B J Carr
Level: 5  Credit value: 15  Semester: B

Overlaps:
- MAS205 Complex Variables

Essential prerequisites:
- MTH4101 Calculus II

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~bjc/MTH5103

Comment: Assessment in 2010–11 was 20% in-term test, 80% final exam
1. Complex numbers, functions, limits and continuity.
2. Complex differentiation, Cauchy-Riemann equations, harmonic functions.
3. Sequences and series, Taylor's and Laurent's series, singularities and residues.
4. Complex integration, Cauchy's theorem and consequences, Cauchy's integral formulae and related theorems.
5. The residue theorem and applications to evaluation of integrals and summation of series.
6. Conformal transformations.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5103

Learning resources

Other texts:
- M R Spiegel, Complex Variables (Schaum Outline)
- R V Churchill & J.W. Brown, Complex Variables and Applications (McGraw Hill)
- H A Priestley, Introduction to Complex analysis (OUP)
- I N Stewart and D O Tall, Complex Analysis (Cambridge University Press)
- G Cain, Complex Analysis
- Tristan Needham, Visual Complex Analysis (Oxford University Press)

MTH731U Computational Statistics

Description
This module introduces modern methods of statistical inference for small samples, which use computational methods of analysis, rather than asymptotic theory. Some of these methods such as permutation tests and bootstrapping, are now used regularly in modern business, finance and science.

Details
Organiser: Dr H Maruri-Aguilar
Level: 7  Credit value: 15  Semester: A

Overlaps:
- MAS344 Computational Statistics
- MAS311 Computational Techniques in Statistics
- MTH6114 Computational Techniques in Statistics

Essential prerequisites:
Either of
- MTH6136 Statistical Theory
- MTH736U Mathematical Statistics

Assessment: 30% coursework, 70% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~maruriag/MTH731U

Comment: Was Semester B in 2010–11

Syllabus
The techniques developed will be applied to a range of problems arising in business, economics, industry and science. Data analysis will be carried out using the user-friendly, but comprehensive, statistics package R.

1. Probability density functions: the empirical cdf; q – q plots; histogram estimation; kernel density estimation.
2. Nonparametric tests: permutation tests; randomisation tests; link to standard methods; rank tests.
3. Data splitting: the jackknife; bias estimation; cross-validation; model selection.
4. Bootstrapping: the parametric bootstrap; the simple bootstrap; the smoothed bootstrap; the balanced bootstrap; bias estimation; bootstrap confidence intervals; the bivariate bootstrap; bootstrapping linear models.

Learning outcomes
- Calculate and interpret the empirical cdf for a univariate set of data. Produce q-q plots for standard probability distributions.
- Use R to produce a kernel density estimate for a univariate set of data.
- Carry out and interpret permutation tests, randomisation tests and rank tests in standard situations.
- Carry out bias estimation using the jackknife.
Use cross validation for model selection in simple situations.
Carry out the parametric bootstrap, the simple bootstrap, the smoothed bootstrap and the balanced bootstrap and use them for bias estimation to produce confidence intervals.
Bootstrap linear models and interpret the results.

Learning resources

Main text:
- J Gentle, Elements of Computational Statistics (Springer)

MTH5104 Convergence and Continuity

Description
This module introduces some of the mathematical theory behind Calculus. It answers questions such as: What properties of the real numbers do we rely on in Calculus? What does it mean to say that a series converges to a limit? Are there kinds of function that are guaranteed to have a maximum value? The module is a first introduction, with many examples, to the beautiful and important branch of pure mathematics known as Analysis.

Details

Organiser: Professor S R Bullett
Level: 5  Credit value: 15  Semester: A

Overlaps:
- MAS111 Convergence and Continuity

Essential prerequisites:
- MTH4100 Calculus I

and
- MTH4104 Introduction to Algebra

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~sb/MTH5104

Comment: Assessment in 2010–11 was 10% coursework, 10% in-term test, 80% final exam

Syllabus

1. Real numbers: Algebraic properties, inequalities, supremum and infimum, completeness axiom for the existence of the supremum.
4. Continuous functions: Definition of continuity and its use in specific examples, sum of continuous functions, composites of continuous functions (proofs), products/quotients of continuous functions (stated). Briefly, the Intermediate Value Theorem, application to roots of polynomials, boundedness of continuous functions on closed bounded intervals.
5. Definition of derivative. Continuity of differentiable functions. (Cover if time permits, also covered at start of next module, Differential and Integral Analysis.)

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5104

Learning resources

Main texts:
  NB: Also very useful for MTH5105 (Differential and Integral Analysis) covering all material except convergence of sequences of functions.

MTH6115 Cryptography
Description
Cryptography is fundamental to commercial life; in particular, the principles of public-key cryptography were a major intellectual achievement of the last century. The module will give you a detailed understanding of the subject.

Details
Organiser: Dr B Noohi

Level: 6  Credit value: 15  Semester: B

Overlaps:
- MAS335 Cryptography

Essential prerequisites:
- MTH4104 Introduction to Algebra

and either of
- MTH5112 Linear Algebra I
- MAS212 Linear Algebra I

Assessment: 10% coursework, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~noohi/MTH6115

Comment: Assessment in 2010–11 was 20% coursework, 80% final exam

Syllabus
1. History and basic concepts: substitution and other traditional ciphers; plaintext, ciphertext, key; statistical attack on ciphers.
2. One-time pad and stream ciphers: Shannon's Theorem; one-time pad; simulating a one-time pad; stream ciphers, shift registers.
3. Public-key cryptography: basic principles, including brief discussion of complexity issues; knapsack cipher; RSA cipher; digital signatures.

Examples of optional topics which may be included: secret sharing, quantum cryptography, the Enigma cipher

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6115

Learning resources
Reading list:
- Dominic Welsh, Codes and Cryptography, Oxford University Press
- Paul Douglas Stinson, Cryptography: Theory and Practice (Chapman and Hall)

MTH6116 Design of Experiments

Description
Experiments are carried out in all areas of business, industry, science and medicine. To obtain reliable information, the experiments must be carefully planned. This module introduces the statistical side of the design of experiments from consultation to interpretation.

Details
Organiser: Dr H Maruri-Aguilar

Level: 6  Credit value: 15  Semester: B

Overlaps:
- MAS314 Design of Experiments

Essential prerequisites:
- MTH6134 Statistical Modelling II

Assessment: 20% coursework, 80% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~maruriag/MTH6116
Syllabus

Real life experiments will be discussed from several applications in business, especially market research, industry and science, including medicine.

1. Treatment structure: factors, main effects, interaction.
2. Completely randomised designs.
4. Row-column designs.
5. Experiments on people and animals.
6. Nested blocks, split-plot designs.
7. General orthogonal designs.
8. Incomplete-block designs.
9. Factorial designs in incomplete blocks.

Seven or eight lectures will be replaced by discussion sessions, when students present their solutions to assignments. Solutions are discussed by the whole class because most questions have no single correct answer.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6116

Learning resources

Reading list:
- Cox, The Planning of Experiments (Wiley)
- John, Statistical Design & Analysis of Experiments (MacMillan)
- Kempthorne, The Design & Analysis of Experiments (Wiley)
- Cochran/Cox, Experimental Design (Wiley)
- Clarke/Kempson, Introduction to the Design & Analysis of Experiments (Arnold)

MTH4102 Differential Equations

Description

This is an applied calculus module, which follows on from the Calculus I and Geometry I modules. The purpose of the module is to develop techniques of solving differential equations and also to show how a higher-order differential equation can be seen geometrically as a vector field. This brings in discussions of matrices, eigenvalues and eigenvectors. Some applications are given.

Details

Organiser: Prof. Y Fyodorov

Level: 4  Credit value: 15  Semester: B

Overlaps:
- MAS112 Modelling Dynamical Systems
- MAS118 Differential Equations

Essential prerequisites:
- MTH4100 Calculus I

and
- MTH4103 Geometry I

Assessment: 20% two in-term tests, 80% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~yan/MTH4102

Syllabus

1. Revision of geometrical meaning of derivative, anti-derivative. Differentiation of combined and composed functions. Verification of solution of differential equation by substitution. Particular and general solutions. The role of initial or boundary conditions. Solution of simplest ODEs by direct integration. Separation of variables for first order differential equations, implicitly defined solutions.
2. First order linear differential equation (integrating factors), homogeneous and inhomogeneous equations.
4. Interpretation of first order differential equation in terms of direction fields, the initial value problem, solution by geometric method.
5. Linear second order differential equations with constant coefficients, homogeneous equations, superposition, characteristic equations, real roots (including degenerate equal roots case), complex roots.
6. Inhomogeneous equations with constant coefficients, method of undetermined coefficients, variation of constants formula, forced oscillations and visualisation.
7. Matrices, eigenvalues and eigenvectors (2-dimensional).
8. Linear systems in two dimensions, reduction of linear second order ordinary differential equation to a linear system in two variables. Various types of solution in terms of exponential functions.
10. The Linearisation Theorem and examples. Linearisation breakdown by examples.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4102

Learning resources

Main text:

MTH5105 Differential and Integral Analysis

Description

This module provides a rigorous basis for differential and integral calculus, i.e. the theory behind differentiation and integration rather than their applications. The module will include some full proofs.

Details

Organiser: Professor O Jenkinson
Level: 5 Credit value: 15 Semester: B
Overlaps:
- MAS221 Differential and Integral Analysis
Essential prerequisites:
- MTH5104 Convergence and Continuity
Assessment: 10% mid-term test, 90% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~omj/MTH5105
Comment: Assessment in 2010–11 was 20% in-term test, 80% final exam

Syllabus

2. Integration: Darboux definition of Riemann integral, simple properties. Continuous functions are integrable (via uniform continuity). Fundamental Theorem of the calculus, integral form of Mean Value Theorem and of the remainder in Taylor's Theorem; applications to some well known series (log, arctan, binomial). Improper integrals.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5105

Learning resources

Main text:
- R Haggarty, Fundamentals of Mathematical Analysis (Addison-Wesley)
Other texts:
- C Clark, Elementary Mathematical Analysis (Wadsworth, 1982)
MTH744U Dynamical Systems

Description

A dynamical system is any system which evolves over time according to some pre-determined rule. The goal of dynamical systems theory is to understand this evolution. This module develops the theory of dynamical systems systematically, starting with first-order differential equations and their bifurcations, followed by phase plane analysis, limit cycles and their bifurcations, and culminating with the Lorenz equations and chaos. Much emphasis is placed on applications.

Details

Organiser: Dr T Prellberg
Level: 7  Credit value: 15  Semester: A

Overlaps:
- MAS424 Introduction to Dynamical Systems
- MTH715U Introduction to Dynamical Systems

Prerequisites: Appropriate level-6 mathematical background; consult the module organiser for details

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~tp/MTH744U

Comment: Renamed from MTH715U/MTHM021 Introduction to Dynamical Systems for 2011–12

Syllabus

1. First-order differential equations (one-dimensional flows): linear and nonlinear equations, graphical solutions, bifurcations.
3. Three-dimensional flows: Lyapunov exponents, Poincare sections, strange attractors, chaos.

Learning outcomes

At the end of this module, students should be able to:

- explain how ordinary differential equations (ODEs) give rise to dynamical systems,
- define the state space, its limit sets and attractors,
- explain how the state space dimension limits the possible dynamics,
- sketch the limit set and, starting from this, characterize the main features in the flow of a dynamical system given by ODEs in the plane,
- explain the concept of chaos in dynamical systems and state some properties of a chaotic dynamical system.

Learning resources

Essential:
- Steven H. Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering (Studies in Nonlinearity)

MTH5106 Dynamics of Physical Systems

Description

Major developments in mathematics have been driven by the desire to describe and explain phenomena in the natural world. This module introduces you to the mathematical and physical concepts used in modelling physical systems. In particular, the module will explore Newton's laws of motion that govern how systems of particles react to forces, particularly gravity.

Details

Organiser: Professor R K Tavakol
Level: 5  Credit value: 15  Semester: A

Overlaps:
MAS226 Dynamics of Physical Systems

Essential prerequisites:

- MTH4101 Calculus II
- MTH4102 Differential Equations

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~reza/MTH5106

Comment: Assessment in 2010–11 was 10% coursework, 10% in-term test, 80% final exam

Syllabus

Some topics may already have been met in A-level Physics or Mechanics.

1. Review of motion in space: displacement, velocity and acceleration using vectors; equation of motion; concept of constants of motion, energy and potentials; circular motion (plane polar coordinates).
2. Mathematical modelling skills; from statement of problem to mathematical model; testing and evaluating a mathematical model.
3. Newton's laws of motion. Examples of different types of motion due to forces and force fields, including resistive forces, and restoring forces: springs, ice hockey and parachutists.
4. Newtonian model of gravity; sphere theorem; projectile motion and escape speed; variable mass: footballs, rockets and black holes.
5. Central forces (e.g. gravity and Coulomb electrostatic forces); conditions for conservative force; potentials and conservation of angular momentum; orbit theory: polar equation of motion, types of orbit, Kepler's Laws: planets, asteroids and impact hazards.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5106

Learning resources

Texts:
- P Smith and R C Smith, Mechanics (Wiley)
- Phil Dyke & Roger Whitworth, Guide 2 Mechanics (Palgrave Mathematical Guides)

MTH740U Electromagnetic Radiation in Astrophysics

Description

This module is an introduction to understanding the origin, propagation, detection and interpretation of electromagnetic (EM) radiation from astronomical objects. In this module students will learn: how to describe EM radiation and its propagation through a medium to an observer; the main processes responsible for line and continuum emission and how they depend on the nature and state the emitting material; the effects of the earth's atmosphere and the operation of the detection process at various wavelengths. The material will be illustrated by examples from optical, infrared and radio portions of the EM spectrum.

Details

Organiser: Professor J P Emerson
Level: 7  Credit value: 15  Semester: B
Overlaps: None
Prerequisites: Appropriate level-6 mathematical background; consult the module organiser for details
Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~jpe/MTH740U

Syllabus

The aims of this module are to:

1. Provide an introduction to the various mechanisms applicable to the creation, propagation and detection of radiation from astronomical objects.
2. Provide an understanding of how EM radiation is generated in astrophysical environments, and how it propagates to the observer on earth, or satellite.
3. Provide an ability to understand astronomical observations and how they can be used to infer the physical and chemical state, and motions
4. Provide an understanding of how spatial, spectral and temporal characteristics of the detection process produce limitations in the interpretation of the properties of astrophysical objects.

5. Provide an understanding of the uncertainties involved in the interpretation of properties of astrophysical objects, including limitations imposed by absorption and noise, both instrumental and celestial, and by other factors.

6. Enable students to be capable of solving intermediate-level problems in astronomical spectra, using analytical techniques encountered or introduced in the course.

Learning outcomes

At the end of this module students will be able to:

- Demonstrate an advanced understanding of the major electromagnetic radiation mechanisms in astrophysics and how the different emission processes (black body, synchrotron, Compton scattering, etc.) are related to fundamental laws and principles of Physics.
- Explain why different astrophysical environments are dominated by different radiation mechanisms depending on physical conditions.
- Analyse how a variety of experimental techniques are used in current astrophysics research to deduce, from spectral information, the properties of astrophysical objects, such as temperature, density, velocity, etc.
- Describe how observational data for electromagnetic radiation is acquired in astronomy, including both space and ground-based techniques.
- Evaluate the importance of the different sources of uncertainty in astronomical observations, as found in current astronomical research.
- Demonstrate a critical evaluation of astronomical data and mathematical techniques as used in current research for analysing electromagnetic radiation from astrophysical objects.
- Select and use appropriate physical concepts and mathematical techniques to solve advanced problems in astrophysical radiation, by identifying the relevant physical principles and translating problems into mathematical statements.

Learning resources

- Astrophysics: Decoding the Cosmos, J Irwin (Wiley 2007)
- Astrophysical Processes, H. Bradt (CUP 2008)
- An Introduction to Modern Astrophysics, BW Carroll and DS Ostlie (Addison-Wesley 1996)

MTH6117 Entrepreneurship and Innovation

Description

The aim of this module is to investigate the processes required to conceive and launch new ventures, including but not limited to enterprises based in mathematics and the sciences. We examine how to cultivate an entrepreneurial mindset and discuss the routes available for turning your ideas into successful ventures. The module provides an introduction to a number of key entrepreneurial skills such as opportunity recognition, market analysis, positioning and branding, pricing, financial planning, bootstrapping, leadership and personnel management, and how to sell yourself and your ideas to investors and other stakeholders.

Details

Organiser: Dr M Wells, City University (Mike.Wells.1 AT city.ac.uk); QM contact Dr V Easson

Level: 6  Credit value: 15  Semester: A

Overlaps:

- DCS341 Entrepreneurship in IT
- PHY333 Entrepreneurship and Innovation

Essential prerequisites:

- A-Level Mathematics or equivalent

Restrictions: Restricted to Queen Mary Mathematical Sciences students.

Assessment: 35% report (group work), 15% presentation (group work), 50% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~fjw/MTH6117

Syllabus

The aim of this module is to increase your awareness of the commercial opportunities available to you in the area of mathematical sciences. We examine how to cultivate an entrepreneurial mind set and discuss the routes available for turning your ideas into business ventures. The module provides an introduction to a number of crucial business skills such as financial planning, business planning and how to sell yourself and your ideas.
Highlight the importance of commercialisation of innovative ideas both in the university and the industrial environment.

2. Creatively explore commercial opportunities within mathematics and science.

3. Introduce the different routes available to take an idea to market.

4. Develop the skills required to start a business venture.

5. Explain the key considerations involved in intellectual property and idea protection.

6. Introduce the key aspects of financial management required in the development of a business venture.

Assessment will include a group 5-page business plan and 10-minute presentation, and an individual 1,000 to 2,000 word essay/report.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6117

Learning resources

Main text:


Optional texts:


MTH3100 Essential Mathematical Skills

Description

A module in basic arithmetic and algebra. Passing this module is compulsory for progression to the second year for students on Mathematical Sciences study programmes.

Details

Organiser: Professor B J Carr

Level: 3 Credit: 0 Semester: A and B

Overlaps:

- MAS010 Essential Mathematical Skills

Prerequisites: A-Level Mathematics or equivalent

Restrictions: Not open to Associate Students.

Assessment: 100% multiple choice exam

Organiser's module website: http://www.maths.qmul.ac.uk/~bjc/MTH3100

Comment: Essential Mathematical Skills (EMS) is described in more detail in the preamble to the study programmes. Please note that we do not accept extenuating circumstances for this module because you already have 4 first attempts and 3 resit attempts within the first academic year.

Syllabus

1. Decompose an integer as a product of prime numbers
2. Calculate the GCD and LCM of a pair of integers
3. Compute quotient and remainder of integer division
4. Simplify arithmetical expressions involving fractions
5. Perform simple estimations
6. Compute quotient and remainder of polynomial division
7. Simplify polynomial and rational expressions
8. Simplify expressions involving square roots
9. Perform algebraic substitutions
10. Solve linear and quadratic equations and inequalities

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH3100

Learning resources
Essential Mathematics web-book

Virtual learning environment:

- Blackboard EMS site. (Log in using your normal Queen Mary computer username and password.)

MTH735U Extrasolar Planets and Astrophysical Discs

Description

Ever since the dawn of civilization human beings have speculated about the existence of planets outside of the Solar System orbiting other stars. The first bona fide extrasolar planet orbiting an ordinary main sequence star was discovered in 1995, and subsequent planet searches have uncovered the existence of more than one hundred planetary systems in the Solar neighbourhood of our galaxy. These discoveries have reignited speculation and scientific study concerning the possibility of life existing outside of the Solar System. This course provides an in depth description of our current knowledge and understanding of these extrasolar planets. Their statistical and physical properties are described and contrasted with the planets in our Solar System. Our understanding of how planetary systems form in the discs of gas and dust observed to exist around young stars will be explored, and current scientific ideas about the origin of life will be discussed. Rotationally supported discs of gas (and dust) are not only important for explaining the formation of planetary systems, but also play an important role in a large number of astrophysical phenomena such as Cataclysmic Variables, X-ray binary systems, and active galactic nuclei. These so-called accretion discs provide the engine for some of the most energetic phenomena in the universe. The second half of this course will describe the observational evidence for accretion discs and current theories for accretion disc evolution.

Details

Organiser: Professor R P Nelson

Level: 7  Credit value: 15  Semester: B

Overlaps: None

Essential prerequisites:

- MTH5102 Calculus III

and

- MTH5106 Dynamics of Physical Systems

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~rpn/MTH735U

Syllabus

Extrasolar planets

1. Detection techniques: Doppler method, transit method, direct detection, microlensing
2. Statistical description of data: mass distribution; orbital properties; correlation with stellar metallicity, physical properties
3. Properties of individual exoplanets and exoplanet systems
4. Comparison with Solar System planets

Planetary system formation model

1. Formation of protoplanetary discs during star formation
2. Protoplanetary disc properties
3. Dust coagulation, runaway growth, oligarchic growth
4. Terrestrial planet formation via giant impacts
5. Giant planet formation: core accretion model versus gravitational instability model
6. Planet migration

Origin of life

1. Definition of life
2. Conditions required for emergence of life – the habitable zone
3. Basic ideas about emergence of self-replicating molecules (RNA, DNA)

Accretion discs

1. Basic accretion disc theory: angular momentum transport mechanisms; diffusion equation for evolution;
2. origin of disc turbulence through the MRI
3. Close binary systems: classification; the Roche potential; Cataclysmic Variables; low and high mass X-ray binaries; outburst phenomena
4. Accretion discs in active galactic nuclei – observations and models
Learning outcomes

Students should:

- have a broad understanding of the statistical and physical properties of the extrasolar planets, and the observational methods used to determine these
- understand how physical principles and simple models of protoplanetary discs can be used to develop theories of planetary formation, and be able to describe current thinking about how planetary systems form
- understand the role that accretion discs play in a broad range of astrophysical phenomena including protostars, close binary systems, and massive black holes, and be able to describe observational evidence of these phenomena
- understand theoretical models of accretion discs based on basic physical and mathematical principles. Be able to derive equations for accretion disc evolution and perform calculations relating to their physical properties.

Learning resources

Main texts:
- Planetary Sciences, I de Pater & J J Lissauer
- Accretion Power in Astrophysics, J Frank, A King, D Raine

MTH711U Extremal Combinatorics

Description

An extremal result is one which determines the extreme value of some parameter over a class of combinatorial structures. A classical example is Mantel's theorem which answers the question: how many edges can a graph have without it containing a triangle. Another instance is the Erdos-Ko-Rado theorem which answers the question: how large can a family of r-subsets of an n-set be if any two of them have non-empty intersection.

This module will cover results of this flavour on both graphs and set systems. There will be an emphasis on techniques as well as results, including the use of linear algebra, probabilistic methods and compressions.

Details

Organiser: Dr O Sisask

Level: 7 Credit value: 15 Semester: A

Overlaps:
- MAS444 Extremal Combinatorics

Helpful prerequisites:

Either of
- MTH6109 Combinatorics
- MAS219 Combinatorics

and either of
- MTH6105 Algorithmic Graph Theory
- MAS236 Algorithmic Graph Theory

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~olof/MTH711U

Comment: Not offered 2010–11

Syllabus

2. The Discrete Cube: Sperner's theorem. Shadows and isoperimetric inequalities (LYM inequality, the Kruskal-Katona theorem, Harper's theorem, edge isoperimetric inequality).
4. Other Topics: other topics of a similar flavour chosen according to class interest and time.

Learning outcomes
After completing this course, students should be able to

- understand the statements of a range of results in extremal graph theory and extremal set theory (detailed in the draft syllabus) and be able to apply these to unfamiliar problems;
- understand the proofs of these results and be able to apply the proof techniques (including compressions, probabilistic and linear algebra methods) to prove similar but unfamiliar results;
- be aware of a few of the more important conjectures and open problems in this subject.

Learning resources

The lecture notes will be self contained. Examples of books giving background material and further reading are:

- B Bollobás, Combinatorics, Cambridge University Press, 1986
- B Bollobás, Modern Graph Theory, Springer-Verlag, 1998
- S Jukna, Extremal Combinatorics: With Applications in Computer Science, Springer-Verlag, 2001

MTH745U Further Topics in Algebra

Description

This module provides exposure to advanced techniques in algebra at an MSc or MSci level. Algebra encompasses familiar objects such as integers, fields, polynomial rings and matrices and has applications throughout mathematics including to geometry, number theory and topology. The module will complement the algebra module offered in Semester A and will cover topics either in commutative or noncommutative algebra. Included will be basic definitions and theorems in either case, normally with rings or fields as a starting point.

Details

Organiser: Professor A MacIntyre

Level: 7  Credit value: 15  Semester: B

Overlaps:
- MTH722U Rings and Modules
- MTHM023 Rings and Modules
- MTH733U Fields and Galois Theory
- MTHM042 Fields and Galois Theory

Essential prerequisites:
- MTH714U Group Theory

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~angus/MTH745U

Comment: New module in 2011–12 to replace "Rings and Modules" and "Fields and Galois Theory".

Syllabus

The aim of this module is to expose students to advanced techniques in algebra, which complement those presented in the module Group Theory. The module is also seen as a way to prepare students to study more advanced algebra subjects at PhD level.

The topics covered will depend on the expertise of the lecturer. These could be drawn from the theory of rings and their modules, Galois theory or elements of algebraic geometry. Commutative algebra or noncommutative algebra could also be covered.

Learning outcomes

- Knowledge and understanding of:
  - Key advanced concepts of algebra (e.g., rings, modules, finite fields, Galois theory)
  - Key applications of algebra (e.g., insolubility of equations of degree greater than or equal to 5 by radicals, equivalence with insolubility of the Galois group)

- Intellectual skills – able to:
  - Apply the concepts learned to appropriate problems in advanced algebra
  - Explain the steps of reasoning used in solving specific problems in advanced algebra

MTH6120 Further Topics in Mathematical Finance

Description
This module develops the ideas discussed in Introduction to Mathematical Finance. As in the former module, concepts from analysis, differential equations, probability and, to some extent, statistics are used to develop further the techniques and language of mathematical finance. The difference is that in this module these techniques are used at a more advanced level.

Details
Organiser: Professor C Beck / Dr M Phillips
Level: 6  Credit value: 15  Semester: B
Overlaps:
- MAS345 Further Topics in Mathematical Finance

Essential prerequisites:
- MTH6121 Introduction to Mathematical Finance

Helpful prerequisites:
Either of
- MTH5118 Probability II
- MTH5121 Probability Models

Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~beck/MTH6120
Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus
1. Revision of: geometric Brownian motion; interest rates and present value analysis; the arbitrage theorem; the Black-Scholes Formula;
   properties of the Black-Scholes option cost; arbitrage strategy.
2. Additional results on option.
3. Valuing by expected utility.
4. Deterministic and probabilistic optimisation models.
5. Exotic options.
6. Some examples beyond geometric Brownian motion models.
7. Autoregressive models and mean reversion.

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6120

Learning resources
Main text:

MTH4103 Geometry I

Description
Properties of two- and three-dimensional space turn up almost everywhere in mathematics. For example, vectors represent points in space, equations describe shapes in space and transformations move shapes around in spaces; a fruitful idea is to classify transformations by the points and shapes that they leave fixed. Most mathematicians like to be able to ‘see’ in special terms why something is true, rather than simply relying on formulas. This module ties together the most useful notions from geometry – which give the meaning of the formulas – with the algebra that gives the methods of calculation. It is an introductory module assuming nothing beyond the common core of A-level Mathematics or equivalent.

Details
Organiser: Dr J N Bray
Level: 4  Credit value: 15  Semester: A
Overlaps:
- MAS114 Geometry I
**Prerequisites:** A-Level Mathematics or equivalent

**Assessment:** 10% mid-term test, 90% final exam

**Organiser's module website:** [http://www.maths.qmul.ac.uk/~jnb/MTH4103](http://www.maths.qmul.ac.uk/~jnb/MTH4103)

**Comment:** Assessment in 2010–11 was 20% in-term test, 80% final exam

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**Syllabus**

1. Phrasebook up to $\mathbb{R}^3$.
2. Vectors in 2-space and 3-space, expressed as $xi + yj + zk$ or as row or column vectors. Addition of vectors. Length of vectors.
3. Vector and cartesian equations of a straight line in $\mathbb{R}^2$ and $\mathbb{R}^3$.
4. Scalar multiple and scalar product of vectors in $\mathbb{R}^2$ and $\mathbb{R}^3$. Cartesian equation of a plane in $\mathbb{R}^3$. Intersections of two or three planes. Solution of families of linear equations in $x, y, z$ by reduction to echelon form.
6. Linear transformations in $\mathbb{R}^2$, expressed by matrices with respect to the standard basis $i, j$. Examples: rotations, reflections, dilations, shears; their matrices.
7. In $\mathbb{R}^2$, characteristic equation, eigenvalues and eigenvectors, trace. Application to the examples in (6) (e.g. rotations with integer trace and the crystallographic restriction).
8. Extension of (6), (7) to $\mathbb{R}^3$.
9. Addition and multiplication of $2 \times 2$ and $3 \times 3$ matrices. Their interpretation as addition and composition of linear transformations. Inversion of matrices in $\mathbb{R}^2$ and in $\mathbb{R}^3$. (Examples and exercises may include $2 \times 3$ and $3 \times 2$ matrices.)

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**Learning outcomes**

[http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4103](http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4103)

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**Learning resources**

**Main text:**
- A E Hirst, Vectors in 2 or 3 dimensions, Elsevier 1995

**Other texts:**
- In addition, Professor Chiswell's notes on Matrices and Geometry will be helpful for some parts of the course, and will be available online.

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**MTH5109 Geometry II: Knots and Surfaces**

**Description**

The module provides a first introduction to abstract ideas of differential geometry of curves and surfaces, with some elements of knot theory and hyperbolic geometry. Building on experience with vectors in three dimensions and elementary calculus, the modules asks what one can say of mathematical interest about an arbitrary curve or surfaces. The module starts with the problem of how to tell if a curve or piece of string is knotted (other than by pulling it about, i.e. mathematically) before moving on to differential geometric (calculus based) methods of measuring properties such as 'torsion' and 'curvature' of a curve or surface. The module ends with exposure to more abstract hyperbolic surfaces and higher-dimensional spaces defined by identifications and symmetries. There will be some proofs.

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**Details**

**Organiser:** Professor S Majid

**Level:** 5  **Credit value:** 15  **Semester:** B

**Overlaps:**
- MAS231 Geometry II: Knots and Surfaces

**Essential prerequisites:**
- MTH4101 Calculus II

and

- MTH4103 Geometry I

**Assessment:** 10% mid-term test, 90% final exam

**Organiser's module website:** [http://www.maths.qmul.ac.uk/~majid/MTH5109](http://www.maths.qmul.ac.uk/~majid/MTH5109)

**Comment:** Assessment in 2010–11 was 20% in-term test, 80% final exam
Syllabus

1. Knots and the unsolved problem of their classification. Reidemeister moves, Jones polynomial. Examples including trefoil, figure-eight.
2. Parametrised regular curves, their curvature and torsion. Unit speed parametrisation and arc length.
3. Principal normal, co-normal and theorem that torsion and curvature can be prescribed up to rigid motions.
4. Planar curves, signed curvature and the winding number theorem.
5. Surfaces, doughnuts and pretzels (classification by number of holes). Surface patches of smooth surfaces.
6. Orientability of a surface and unit normal. Examples of orientable and non-orientable surfaces such as Möbius band.
7. Studying curves lying in surfaces. First fundamental form, second fundamental form, geodesics and normal curvatures.
10. Gauss-Bonnet theorem for closed surfaces, for simple closed curves and for curvilinear $n$-gons.
11. Non-examinable discussion of higher-dimensional spaces and/or another topic.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5109

Learning resources

Essential:

Recommended:
- C Bar, Elementary Differential Geometry, Cambridge University Press, 2010

Advanced knot theory:

MTH714U Group Theory

Description

This module provides an introduction to advanced group theory. The aim is to explore the theory of finite groups by studying important examples in detail, such as simple groups. In particular, the projective special linear groups over small fields provide a rich vein of interesting cases on which to hang the general theory.

Details

Organiser: Professor P J Cameron
Level: 7 Credit value: 15 Semester: A

Overlaps:
- MAS428 Group Theory

Essential prerequisites:
- MTH5100 Algebraic Structures I

and

Helpful prerequisites:
- MTH6104 Algebraic Structures II

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~pjc/MTH714U

Syllabus

1. Revision of basic group theory, isomorphism theorems, Jordan-Holder theorem, Sylow's theorems, the structure theorem for finite abelian groups.
3. Linear groups: finite fields, general linear groups, projective special linear groups. Projective lines and isomorphisms of some projective
special linear groups with alternating groups. Simplicity of $\text{PSL}_n(q)$.

### Learning outcomes

A knowledge of those basic theorems in group theory mentioned in the syllabus, some knowledge of how those topics have developed in recent times and a feeling for how one goes about proving results in group theory.

### Learning resources

The recommended text is J. L. Alperin and R. W. Bell, Groups and Representations, Springer (1995). Chapters 1 to 4 cover most (but not all) of what is in this module, plus a little extra, including the required background from Algebraic Structures II.

### MTH4104 Introduction to Algebra

**Description**

This module is an introduction to the basic notions of algebra, such as sets, numbers, matrices, polynomials and permutations. It not only introduces the topics, but shows how they form examples of abstract mathematical structures such as groups, rings and fields, and how algebra can be developed on an axiomatic foundation. Thus, the notions of definition, theorem and proof, example and counterexample are described. The module is an introduction to later modules in algebra.

**Details**

- **Organiser:** Dr K Ardakov
- **Level:** 4  
  **Credit value:** 15  
  **Semester:** B
- **Overlaps:**
  - MAS117 Introduction to Algebra
- **Essential prerequisites:**
  - MTH4103 Geometry I
- **Helpful prerequisites:**
  - Either of
    - MTH4107 Introduction to Probability
    - MTH4108 Probability I
- **Assessment:** 20% two in-term tests, 80% final exam
- **Organiser's module website:** [http://www.maths.qmul.ac.uk/~ardakov/MTH4104](http://www.maths.qmul.ac.uk/~ardakov/MTH4104)

**Syllabus**

1. Mathematical basics: proofs, necessary and sufficient conditions, proofs and counterexamples, definitions, existence and uniqueness.
3. Sets, subsets, functions, relations. One-to-one and onto functions. Equivalence relations and partitions.
5. Rings and fields, ideals, factor rings.
7. Permutations, symmetric group, sign.

**Learning outcomes**

[http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4104](http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4104)

**Learning resources**

**Reading list:**

This module focuses on showing how to use Maple to do mathematics that you know from A-level or are learning in the first semester and introduces programming concepts that are relevant to mathematical computing. Coverage is broad but fairly superficial. The module is pragmatic and uses Maple’s worksheet interface and packages where appropriate.

Details

Organiser: Professor R Whitty

Level: 4  Credit value: 15  Semester: A

Overlaps:

• MAS116 Introduction to Mathematical Computing

Prerequisites: A-Level Mathematics or equivalent

Assessment: 20% two in-term tests, 80% final exam

Organiser’s module website: http://www.maths.qmul.ac.uk/~whitty/MTH4105

Syllabus

Part I – Interactive Mathematical Computing

1. Introduction to Maple: The Maple worksheet; online help; execution groups and text regions; basic computational number systems (integer, rational, float); simple arithmetic operations; factorial (!) and big numbers; Pi and numerical approximation using evalf; %; comma operator and expression sequences; command completion.

2. Continuous Mathematics: Variables, assignment and automatic evaluation; indeterminates and (univariate) polynomials; simple polynomial algebra; expand, factor, simplify; sqrt, exp, log and trigonometric functions; substitution and evaluation using eval; equations and inequalities; solve and fsolve; diff; int and evalf(Int ...); limit; series and taylor.

3. Discrete Mathematics: Integer arithmetic, divisibility and prime numbers: irem, iquo, igcd, ifactor, isprime; structured data: sequences, lists and sets; seq; nops; indexing using op and [ ]; index ranges; set operations; map; add, mul, sum.

4. Vectors, Matrices and Multivariate Algebra: Inputting row/column vectors and matrices; Vector and Matrix; vector and matrix algebra; scalar and vector product; exact and approximate eigenvalues and eigenvectors. Multivariate expressions; solving coupled multivariate equations.

5. Plotting and Tabulating: plotting univariate expressions; multiple plots; using the graphical user interface to read off intersections; lists of points; bivariate expressions as surfaces; 2D curves and 3D surfaces defined implicitly and parametrically; vectors; linear transformations; ellipses, ellipsoids and eigenvectors. Introduction to spreadsheets.

Part II – Mathematical Programming

1. Boolean Logic: Boolean constants (true, false); relational operators, evalb, is; use of evalf; Boolean operators (and, or, not); truth tables (using spreadsheets); Boolean algebra; analogy with set theory.

2. User-defined Functions: Arrow syntax; anonymous and named functions; polynomial and elementary transcendental examples; use with map; predicates (Boolean-valued functions); select and remove.

3. Repeated Execution: do ... end do; for ... to; while; for ... in; applications such as recursive sequences and iterative approximation, e.g. Iterative method for solving univariate equations, power method for largest eigenvalue; single/double loops over vector/matrix elements.

4. Conditional Execution: if ... then ... end if; else; elif; applications within loops (e.g. finding the maximum value in a list, vector or matrix and convergence of iterations); piecewise-defined functions; characteristic functions on sets; use with add.

5. Procedures: proc ... end proc; variable scope; local; global; return value versus side effects; return; error; print; applications such as base conversion, simple statistics.

6. Procedural Programming: The use of procedures for structuring programs; converting algorithms into programs; program design; debugging.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4105

Learning resources

You may find the following books useful:

• F Vivaldi, Experimental Mathematics with Maple, Chapman & Hall, CRC Press 2001
• F J Wright, Computing with Maple, Chapman & Hall, CRC Press 2001

MTH6121 Introduction to Mathematical Finance

Description

This module provides an introduction to the ideas of Mathematical Finance. It uses concepts from analysis, differential equations and probability to develop the techniques and language of Mathematical Finance.

Details
Organiser: Dr O Bandlow

Level: 6  Credit value: 15  Semester: A

Overlaps:
- MAS343 Introduction to Mathematical Finance

Essential prerequisites:
- MTH4101 Calculus II

and any of
- MTH4107 Introduction to Probability
- MTH4108 Probability I
- MAS108 Probability I

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~ob/MTH6121

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

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**Syllabus**

1. Pointers/revision of probability concepts: probability and events, conditional probability, random variables and expected values, covariance and correlation. Normal random variables and their properties, central limit theorem.
3. Interest rates and Present Value Analysis – including rate of return and continuously varying interest rates.
4. Pricing contracts via arbitrage – options pricing and examples.
5. The arbitrage theorem – proof and interpretation.
7. A derivation of the Black-Scholes formula.

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**Learning outcomes**

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6121

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**Learning resources**

Main text:

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**MTH5110 Introduction to Numerical Computing**

**Description**

This module investigates the use of computer algebra, numerical techniques and computer graphics as tools for developing the understanding and the solution of a number of problems in the mathematical sciences. Topics that will be addressed will include linear algebra, the solution of algebraic equations, the generation and use of quadrature rules and the numerical solution of differential equations and, time permitting, some other aspects of computational mathematics. The computer language used is Maple.

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**Details**

Organiser: Dr W Just

Level: 5  Credit value: 15  Semester: B

Overlaps:
- MAS235 Introduction to Numerical Computing

Essential prerequisites:
- MTH4101 Calculus II

and
- MTH4103 Geometry I

and
MTH4105 Introduction to Mathematical Computing

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~wj/MTH5110

Syllabus

This course investigates the use of computer algebra, numerical techniques and computer graphics as tools for developing the understanding and the solution of a number of problems in the mathematical sciences. The computer algebra system used for this course will be Maple.

1. Brief revision of Maple. Tracing algorithms and debugging.
2. Numerical and symbolic operations on matrices: obtaining and examining the properties of eigenvalues and eigenvectors.
4. Integration: overview of numerical techniques, symbolic generation of quadrature rules, comparison of numerical integration using numerical techniques and using symbolic analysis.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5110

Learning resources

Reading list:
- F J Wright, Computing with Maple, Chapman & Hall/CRC (2001)

MTH4107 Introduction to Probability

Description

This is the first course in probability, covering events and random variables. It introduces the basic notions of probability theory and develops them to the stage where one can begin to use probabilistic ideas in statistical inference and modelling, and the study of stochastic processes.

The first section deals with events, the axioms of probability, conditional probability and independence. The second introduces random variables both discrete and continuous, including distributions, expectation and variance. Joint distributions are covered briefly.

Details

Organiser: Dr R Johnson

Level: 4   Credit value: 15   Semester: A

Overlaps:

- MAS108 Probability I

Prerequisites: A-Level Mathematics or equivalent

Assessment: 20% two in-term tests, 80% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~jrj/MTH4107

Syllabus

1. Probability: frequentist vs modelling vs subjective. Finite sample spaces (equiprobable or not); events as subsets. Sets, subsets, membership, set notation, union, intersection, complement, setminus. Commutative, distributive, and de Morgan’s laws. Ordered and unordered pairs and higher products.
2. Functions, including domain, codomain, composition of functions, one-to-one, onto, bijections, inverse functions. Sequences: suffix notation, summation notation, change of suffix, manipulating sums.
3. Elementary ideas of probability theory; Kolmogorov axioms; additivity of probabilities of disjoint events. Sigma notation with suffix i. Simple proofs from the axioms. Inclusion-exclusion. Propositions, logical operations, negation, and, or, converse, equivalent, ideas of proof.
5. Independent events: definition, examples. Multiplication law. Three or more events.
6. Conditional probability. Definition. Sampling without replacement done in stages rather than as set of outcomes. Proof by induction that \( P(E_1 \cap E_2 \cap ... \cap E_n) = P(E_1) \times P(E_2 | E_1) \times ... \times P(E_n | E_1 \cap ... \cap E_{n-1}) \). Theorem of Total Probability. Use sigma notation with suffix i.
7. Bayes’ Theorem and its use to calculate ‘inverse’ probabilities like conditional probability of having disease D given that test for D is positive. Discrete random variables as functions from sample space to \( \mathbb{R} \).
8. Probability mass function, mean. Variance. Mean and variance of a \( X + b \).
9. Familiarity with the following distributions (including pmf, mean, variance, what they are used to model): Bernoulli, binomial, geometric, hypergeometric, Poisson. Cumulative distribution function for discrete random variables. Informal introduction to continuous random variables. Cumulative distribution function, probability density function. Mean, variance. \( E(g(X)) \). Median and quartiles.


Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4107

Learning resources

Main texts:
- Lindley/Scott, New Cambridge Statistical Tables (CUP)
- S Ross, A First Course in Probability (Prentice Hall)

Other texts:
- Hines/Montgomery, Probability & Statistics in Engineering & Management Science (Wiley)
- J A Rice, Mathematical Statistics & Data Analysis (Wadsworth)

MTH4106 Introduction to Statistics

Description

This first module in statistics introduces the fundamental ideas of classical statistics. It covers descriptive statistics, the estimation of population moments using data and the basic ideas of statistical inference, hypothesis testing and interval estimation. These methods will be applied to data from a range of applications, including business, economics, science and medicine. A simple statistics package will be used to perform the calculations.

Details

Organiser: Professor R A Bailey

Level: 4  Credit value: 15  Semester: B

Overlaps:
- MAS113 Fundamentals of Statistics I
- MAS113X Fundamentals of Statistics I
- MTH4109 Fundamentals of Statistics I
- ECN104 Introductory Statistics for Economics and Business

Essential prerequisites:
- MTH4100 Calculus I

and either of
- MTH4107 Introduction to Probability
- MTH4108 Probability I

Helpful prerequisites:
- MTH4101 Calculus II

Assessment: 20% two in-term tests, 80% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~rab/MTH4106

Syllabus


4. Hypothesis tests on proportions, basic ideas, type I and II errors. One- and two-sided alternative hypotheses.

Introduction to joint distribution of two or more continuous rvs. Covariance, correlation and independence. Point estimation. Unbiasedness of sample mean and variance, calculation of bias.

5.

Normal rv, standard and general. Use of normal tables. Simulation – how to sample from different distributions, simulation of simple functions of rvs.

6.

Introduction to joint distribution of two or more continuous rvs. Covariance, correlation and independence. Point estimation. Unbiasedness of sample mean and variance, calculation of bias.

7.

Statements of law of large numbers and central limit theorem. Simulations of theoretical results. Linear combinations of normal rvs. Normal approximation to binomial and Poisson rvs, continuity correction. Sampling distributions of sample total, mean and variance.

8.

1-sample $z$ test. Significance levels and $p$-values. Large sample applications.

9.

Confidence intervals (CIs) – general ideas, CI for normal mean and large sample applications. Confidence intervals for a Poisson mean.

10.


Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH4106

Learning resources

Main texts:

A book which suits YOU best to learn statistics is best (for you). You are encouraged to use it, whether it is one from the list below or another one.


You should already have a copy of:


MTH5112 Linear Algebra I

Description

This is a rigorous first module in linear algebra. The ideas introduced in Geometry I for two- and three-dimensional space will be developed and extended in a more general setting with a view to applications in subsequent pure and applied mathematics, probability and statistics modules. There will be a strong geometric emphasis in the presentation of the material and the key concepts will be illustrated by examples from various branches of mathematics. The module contains a fair number of proofs.

Details

Organiser: Professor C-H Chu

Level: 5  Credit value: 15  Semester: A

Overlaps:

- MAS212 Linear Algebra I

Essential prerequisites:

- MTH4103 Geometry I

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~cchu/MTH5112

Comment: Assessment in 2010–11 was 10% coursework, 10% in-term test, 80% final exam

Syllabus


5. Linear Transformations: Definition and examples. Matrix representations of linear transformations. The law of change of matrix representation under a change of basis. The Rank-Nullity Theorem.

7. Eigenvalues and Eigenvectors: The equation $A\mathbf{x} = \lambda \mathbf{x}$. The characteristic polynomial. Eigenvalues and eigenvectors of special classes of matrices. Real symmetric matrices: orthogonal diagonalisation. Similarity: distinct eigenvalues and diagonalisation.

**Learning outcomes**

On passing this module students should be able to:

- Solve linear systems and write solutions in vector form.
- Multiply matrices, including rectangular ones, and calculate the transpose of a matrix where the entries are either scalars or algebraic expressions.
- Use algebraic equations $A(B + C) = AB + AC$, $(AB)^T = BA^T$, etc., both with letters for matrices and with examples of matrices whose entries are either scalars or algebraic expressions.
- Determine whether a given matrix is invertible or not. Calculate the inverse of an invertible matrix.
- Calculate the determinant of a square matrix (for small matrix dimensions).
- Determine whether or not a given subset of a vector space is a subspace.
- Determine whether or not a given vector is in the subspace spanned by a set of vectors.
- Determine whether given vectors (i) are linear independent, (ii) form a basis for a vector space.
- Find the coordinates of a vector with respect to a given ordered basis.
- Calculate the transition matrix corresponding to a change of basis.
- Calculate the rank of a matrix.
- Given a mapping from one vector space to another, verify whether it is linear or not.
- Given a linear mapping from one vector space to another, calculate the matrix of the mapping with respect to given bases.
- Calculate the scalar product of two vectors and determine whether the vectors are (i) orthogonal, (ii) orthonormal.
- Find the orthogonal projection of a vector onto a given subspace. Given a vector $\mathbf{y}$ and a subspace $S$, find the vector in $S$ that is closest to $\mathbf{y}$.
- Determine the set of least-squares solutions of a given linear system.
- Be able to apply the Gram-Schmidt process.
- Determine bases for the row and column spaces of a matrix.
- Calculate eigenvalues and eigenvectors of a square matrix.
- Given a real square matrix $A$ with distinct eigenvalues, find an invertible matrix $P$ such that $P^{-1}AP$ is diagonal.
- Given a real symmetric matrix $A$, find an orthogonal matrix $Q$ such that $Q^TAQ$ is diagonal.
- Be able to put together a mathematical argument in order to deduce/prove simple facts about vectors, matrices, vectors spaces and linear maps.

**Learning resources**

Main text:
- S J Leon: Linear Algebra with Applications. 7th Ed. (Pearson)

**MTH6140 Linear Algebra II**

**Description**

This module is a mixture of abstract theory, with rigorous proofs, and concrete calculations with matrices. The abstract component builds on the theory of vector spaces and linear maps to construct the theory of bilinear forms (linear functions of two variables), dual spaces (which map the original space to the underlying field) and determinants. The concrete applications involve ways to reduce a matrix of some specific type (such as symmetric or skew-symmetric) to as near diagonal form as possible.

**Details**

Organiser: Professor T Müller

Level: 6  Credit value: 15  Semester: A

Overlaps:
- MAS317 Linear Algebra II

Essential prerequisites:
- MTH4104 Introduction to Algebra

and
- MTH5112 Linear Algebra I

Assessment: 100% final exam
Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus

2. Orthogonality, the Gram-Schmidt orthogonalisation process, orthogonal projections.
3. Revision of vector spaces, subspaces, eigenspaces, linear maps, direct sum, kernel and image, spanning set, linear independence, basis, dimension, Steinitz Exchange Lemma, dimension formula for subspaces, with rigorous proofs.
5. Linear functional, dual spaces, equality of row and column rank of a matrix.
7. Simultaneous diagonalisation, for linear map and positive definite symmetric form, and for two symmetric forms.

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6140

Learning resources

Main text:
- S Lipshutz, Linear Algebra (2nd edition) (Schaum Outline Series)

MTH717U MSci Project

Description
You will write a report that must present the study of some mathematical topic at fourth-year undergraduate level and must be your own work in the sense that it gives an original account of the material, but it need not contain new mathematical results. The list of potential projects and supervisors is available on the School of Mathematical Sciences website. You will be accepted for a specific project only after agreement between the module organiser and the project supervisor.

Details

Organiser: Professor L H Soicher
Level: 7  Credit value: 30  Semester: A and B

Overlaps:
- MAS410 MSci Project

Essential prerequisites:
- You should begin preparation over the summer and before registering you must consult the module organiser.

Helpful prerequisites:
- MTH5117 Mathematical Writing

Restrictions: Not open to Associate Students.

Assessment: Written report, presentation and (possibly) oral exam

Organiser's module website: http://www.maths.qmul.ac.uk/~leonard/MTH717U

Syllabus

A project in any area of mathematics, including astronomy and computing, which normally runs over both of semesters 7 and 8. The project will be assessed primarily by a written report and, at the examiners' discretion, an oral examination, but also by a presentation of about 30 minutes in duration, to be given towards the end of semester 8. The contribution of the presentation will be on a sliding scale that will never decrease the project mark by more than 10% or increase it by more than 20%, and provided you make a reasonable attempt at giving a presentation it will not decrease your project mark.

Your report must present the study of some mathematical topic at fourth-year undergraduate level and must be your own work in the sense that it gives an original account of the material, but it need not contain new mathematical results. To obtain a mark above a bare pass it is not sufficient to read several sources on the project topic and then write about this topic in your own words; you must also make some original contribution. For example, you might do one or more of the following: give a new interpretation or view of the mathematics; give new examples; do your own
detailed calculations or data analysis; write, test and run your own computer program. You must make it completely clear where you are providing your own original contribution rather than paraphrasing published information. The length should be about 8000 words; if it is less than 6000 or more than 10000 words you may lose marks. You can write your report in a single semester or spread over two semesters, depending on your other module choices.

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Learning outcomes

Not yet available

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INE6001 Mathematical Education for Physical and Mathematical Sciences

Description

This module is for undergraduates in mathematics or in the physical sciences who are interested in studying mathematics education. 'Mathematics education' is an umbrella term that encompasses all aspects of learning and teaching mathematics in schools and in other settings.

Details

Organiser: Dr M Rodd, Institute of Education; QM contact Dr F Wright

Level: 6  Credit value: 15  Semester: A and B

Overlaps: None

Essential prerequisites:

- A second-year mean mark of at least 50%

Restrictions: Restricted to Queen Mary Mathematical Sciences students. Not open to Associate Students.

Assessment: 50% coursework essay (to be submitted towards the end of Semester B) and 50% final exam (to be sat in May)

Organiser's module website: [http://www.maths.qmul.ac.uk/~fjw/INE6001](http://www.maths.qmul.ac.uk/~fjw/INE6001)

Comment: Note that this module spans both semesters.

Syllabus

The aim of this module is to introduce you to central ideas of mathematical education. It should be relevant to you if you are considering going into teaching after you graduate and it will also be relevant to you as a learner of mathematics. This module is valued by Queen Mary as 15 credits at level 6 and may be taken as one of the non-MTH modules allowed in the third or final year of all Mathematical Sciences study programmes.

The module will be taught at the Institute of Education (IoE) at 20, Bedford Way, seven minutes walk from Euston Square tube station. Lectures will take place during both of Semesters A and B on Mondays from 5:00pm to 6:30pm for 19 sessions starting on 3 October 2011 and excluding reading weeks. When considering your timetable, you should allow 45 minutes travel time from Queen Mary to the Institute of Education. This means that you will not be able to attend any classes at Queen Mary after 4:00pm on Mondays. Individual tutorials will be arranged during Semester B to help with essay writing, and revision session(s) will be held late April / early May to help prepare for the exam.

There will be a preliminary meeting at 5:00pm on Monday 26 September 2011 in room 203 in the Mathematical Sciences Building, Queen Mary, which you are advised to attend before deciding whether to take this module.

You can select this module in MySIS as one of your options, but note the prerequisite that you must have a second-year mean mark of at least 50%. (We will check this!) The IoE code for this module is DDOPRO_69. You will also need to complete an intercollegiate module registration form, get it signed by the module organiser at the IoE, and return it to Dr Francis Wright. (You do not need any other signatures from Queen Mary.) This form is necessary for your results to be transferred from the IoE to Queen Mary. Forms will be available at the preliminary meeting or you can obtain one from Queen Mary Registry.

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Learning outcomes

- You'll have a better understanding of your own mathematics-learning strategies and capacities.
- You'll be able to explain how mathematical ideas can be represented in different ways with various tools or media.
- You'll have a coherent view on the content of the school maths curriculum and how maths should be taught.
- You'll be able to discuss some of the wider social and political issues related to mathematics education.
- You'll have developed your skills in presenting ideas about mathematics in writing; this includes expressing views and observations, synthesising readings and presenting arguments.

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MTH6124 Mathematical Problem Solving

Description
The module is concerned with solving problems rather than building up the theory of a particular area of mathematics. The problems are wide ranging with some emphasis on problems in pure mathematics and on problems that do not require knowledge of other undergraduate modules for their solution. You will be given a selection of problems to work on and will be expected to use your own initiative and the library. However, hints are provided by staff in the timetabled sessions. Assessment is based on the solutions handed in, together with an oral examination.

Details
Organiser: Dr D Ellis
Level: 6  Credit value: 15  Semester: B
Overlaps:
- MAS330 Mathematical Problem Solving
Prerequisites: Appropriate level-5 mathematical background; consult the module organiser for details
Assessment: Written solutions to questions and oral exam
Organiser's module website: http://www.maths.qmul.ac.uk/~dellis/MTH6124
Comment: This is a reading module (i.e. primarily self-study). Places are limited; contact the module organiser to validate registration.

Syllabus
The course is concerned with solving problems rather than building up the theory of a particular area of mathematics. The problems cover a wide range, with some emphasis on problems in pure mathematics and on problems which do not require knowledge of other undergraduate courses for their solution. Students are given a selection of problems to work on and are expected to use their own initiative and the library; however hints are provided by the staff at the timetabled sessions.

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6124

MTH736U Mathematical Statistics

Description
This module covers the classical theory of statistical inference and the probability theory which are required for more advanced study in statistics. It is aimed at mathematicians who have done little statistics in their previous undergraduate studies. It will cover material which is in the equivalent of approximately two undergraduate modules, at a fast pace and taking a mathematical approach. Students will have considerably more responsibility for their own learning than they would have in undergraduate modules covering the same material. Topics covered include: conditional probability; hypothesis testing; distribution theory; estimation; multivariate normal distribution; Laws of Large Numbers and the Central Limit Theorem; confidence intervals; general theory of testing; matrix algebra; least squares; Gauss-Markov Theorem.

Details
Organiser: Dr B Bogacka
Level: 7  Credit value: 15  Semester: A
Overlaps:
- MAS230 Fundamentals of Statistics II
- MTH5122 Statistical Methods
- MTH6136 Statistical Theory
Essential prerequisites:
- MTH4101 Calculus II
and
- MTH4106 Introduction to Statistics
and
- MTH5112 Linear Algebra I
Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~bb/MTH736U
Syllabus

This is a condensed statistics module intended primarily for MSc students with little statistical background; undergraduate students are strongly encouraged to take MTH6136 Statistical Theory instead.

1. Probability Distribution Theory:
   - families of probability distributions;
   - functions of random variables;
   - conditional expectation;
   - common probability distributions;
   - multivariate random variables, marginal distributions, independence;
   - moment generating functions; correlation;
   - multivariate normal random variables;
   - distribution of quadratic forms;
   - Laws of Large Numbers and the Central Limit Theorem.

2. Statistical Inference:
   - principles of data reduction including: sufficiency, likelihood, invariance;
   - point estimation including: properties of estimators (consistency, bias, minimum variance), Cramer-Rao lower bound, methods of estimation (method of moments, maximum likelihood, least squares), asymptotic properties;
   - interval estimation including: pivotal quantities, approximate maximum likelihood CIs, methods of evaluating interval estimators;
   - hypothesis testing including: statistical hypotheses, type I and II errors, power, Neyman-Pearson lemma, likelihood ratio tests, Wilks’ theorem.

Learning outcomes

Ability to use probability to solve problems in mathematical statistics. Knowledge of the general principles of frequentist and likelihood inference. Ability to apply the general principles to specific methodological problems.

Learning resources

Reading list:
- J A Rice, Mathematical Statistics and Data Analysis (Duxbury)
- D Wackerley, W Mendenhall and R L Scheaffer, Mathematical Statistics with Applications (Duxbury)

MTH5117 Mathematical Writing

Description

This module teaches the language of higher mathematics, and how to use it with precision and fluency in a variety of contexts. For raw material, it calls on the mathematics developed in the first year, which you will see from a more mature perspective. The module also develops some elements of logic that serve as the basis for an analysis of the main techniques used in mathematical proofs. You will get a lot of practice and feedback through the coursework.

Details

Organiser: Professor F Vivaldi

Level: 5  Credit value: 15  Semester: A

Overlaps:
- MAS233 Logic I: Mathematical Writing
- MAS237 Mathematical Writing

Essential prerequisites:
- MTH4104 Introduction to Algebra

Assessment: 20% coursework, 80% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~fv/MTH5117

Syllabus

1. Basic words and symbols of higher mathematics.
3. Describing the behaviour of functions.
4. Logical structures: the predicate algebra.
5. Basic proof techniques.
7. Natural numbers: inductive arguments.
8. Definitions: what they are for and how to write them.
9. Intellectual property: giving credit, respecting copyright

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5117

Learning resources

Essential:

Highly recommended:

Recommended:
- G Chartrand, A Polymeny, and P Zhang, Mathematical proofs, a transition to advanced mathematics, Addison-Wesley (2003)

MTH716U Measure Theory and Probability

Description

This is an introductory module on the Lebesgue theory of measure and integral with application to probability. You are expected to know the theory of Riemann integration. Measure in the line and plane, outer measure, measurable sets, Lebesgue measure, non-measurable sets. Sigma-algebras, measures, probability measures, measurable functions, random variables. Simple functions, Lebesgue integration, integration with respect to general measures. Expectation of random variables. Monotone and dominated convergence theorems, and applications. Absolute continuity and singularity, Radon-Nikodym theorem, probability densities. Possible further topics: product spaces, Fubini's theorem.

Details

Organiser: Professor O Jenkinson
Level: 7  Credit value: 15  Semester: A

Overlaps:
- MAS409 Measure Theory and Probability

Essential prerequisites:
- MTH5105 Differential and Integral Analysis

Helpful prerequisites:
- MTH6126 Metric Spaces

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~omj/MTH716U

Comment: Was Semester B in 2010–11

Syllabus

This is an introductory course on the Lebesgue theory of measure and integral with application to Probability. Students are expected to know the theory of Riemann integration.

1. Measure in the line and plane, outer measure, measurable sets, Lebesgue measure, non-measurable sets.
2. Sigma-algebras, measures, probability measures, measurable functions, random variables.
4. Absolute continuity and singularity, Radon-Nikodym theorem, probability densities.
5. Possible further topics: product spaces, Fubini's theorem.
Learning outcomes
Not yet available

MTH6126 Metric Spaces

Description
The study of metric spaces provides a link between geometry, which is fairly concrete, and topology, which is more abstract. It generalises to multidimensional spaces the concepts of continuity and other ideas studied in real analysis and explores the foundations of continuous mathematics.

Details
Organiser: Dr D Stark
Level: 6 Credit value: 15 Semester: A
Overlaps: None
Essential prerequisites:
- MTH5104 Convergence and Continuity
Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~dstark/MTH6126
Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus
1. Definition of metric space; examples, including finite metric spaces, function spaces, normed vector spaces, product spaces.
2. Convergence and continuity in metric spaces.
3. Equivalent metrics.
4. Open and closed sets, properties, continuity in terms of pre-images of open sets.
5. (Sequential) compactness, properties of compact spaces, uniform continuity, Bolzano-Weierstrass Theorem.
6. Completeness; examples, including C[0,1]. Examples of completions of metric spaces. Contraction mappings, Banach fixed-point theorem, applications, e.g., to solutions of differential equations.
7. Further topics if time allows, such as the Heine-Borel Theorem.

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6126

Learning resources
Main texts:
- W A Sutherland, Introduction to Metric and Topological Spaces, OUP 1975 (chapters 2, 5–9)

MTH6128 Number Theory

Description
This module introduces some of the more elementary aspects of algebraic number theory from a classical perspective. The main strands are continued fractions, binary quadratic forms and modular arithmetic. The theory of continued fractions serves as a unifying theme as well as a source of algorithms. Applications include the representation of primes as sums of squares and the solution of Pell's equation.

Details
Organiser: Professor P J Cameron
Level: 6 Credit value: 15 Semester: B
Overlaps:
- MAS320 Number Theory
Essential prerequisites:
MTH4104 Introduction to Algebra

Assessment: 100% final exam

Organiser's module website: [http://www.maths.qmul.ac.uk/~pjc/MTH6128](http://www.maths.qmul.ac.uk/~pjc/MTH6128)

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

**Syllabus**

1. Continued fractions: finite and infinite continued fractions, approximation by rationals, order of approximation.
2. Continued fractions of quadratic surds: applications to the solution of Pell's equation and the sum of two squares.

**Learning outcomes**

[http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6128](http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6128)

**Learning resources**

Main texts:


MTH6129 Oscillations, Waves and Patterns

**Description**

Waves and vibrations are present in almost all physical systems, from the vibrations in strings to the waves of the oceans and atmosphere. Waves and patterns are also seen in chemical and living systems. This module is an introduction to the mathematical theory of waves, dealing with the solution of differential equations describing, for example, vibrations on strings and waves in fluids. Elementary ideas about nonlinear waves, such as shock formation, are described. The material is illustrated with applications from a wide variety of different systems.

**Details**

Organiser: Professor J Lidsey

Level: 6  Credit value: 15  Semester: B

Overlaps:

- MAS229 Oscillations, Waves and Patterns
- PHY217 Vibrations and Waves

Essential prerequisites:

- MTH5102 Calculus III

and

- MTH5106 Dynamics of Physical Systems

Assessment: 100% final exam

Organiser's module website: [http://www.maths.qmul.ac.uk/~jel/MTH6129](http://www.maths.qmul.ac.uk/~jel/MTH6129)

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

**Syllabus**

1. Oscillations: Review of restoring forces and SHM; damped oscillations, strong, weak and critical damping; forced damped oscillations, transient and steady state solutions; resonance.
2. Coupled oscillators: normal coordinates, normal modes of vibrations, derivation of wave equation as the limit of many coupled oscillators.
3. Waves: derivation of classical wave equation for string; D'Alembert's solution; travelling plane wave solutions; transverse vibrations on a string; harmonic waves, normal modes for string fixed at ends, solution by separation of variables; initial conditions and Fourier sine series; examples, such as vibrations and musical sounds.
4. Waves in fluids: linear surface waves on deep and shallow water; dispersion relation, phase and group velocities; waves on inclined beds, tsunamis.
5. Patterns: circular membranes (drums): modes of oscillation and their patterns; nonlinear waves and solitons; qualitative introduction to waves and pattern formation in other systems, e.g. biological and chemical systems.
Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6129

Learning resources

Other texts:
- Vibrations and Waves: A P French (Chapman and Hall)
- The Physics of Vibrations and Waves: H J Pain (John Wiley and Sons)
- Vibrations and Waves in Physics: I G Main (Cambridge University Press)
- Wave Motion: Billingham and A C King (Cambridge University Press)
- Physics of Waves: W C Elmore and M A Heald (McGraw-Hill)
- Waves: C A Coulson (Oliver and Boyd)
- Wave Physics: S Nettel (Springer Verlag)

MTH5121 Probability Models

Description

This module develops some of the ideas first introduced in Introduction to Probability (Probability I). It will cover five main topics: how to compute probabilities and expectations by a process called conditioning; random walks and other discrete branching processes; continuous methods of conditioning; continuous probability models such as Poisson processes; and some very useful limit theorems. The material is important for applications in financial and actuarial mathematics, in the physical and life sciences, and for more advanced probability modules.

Details

Organiser: Professor I Goldsheid

Level: 5 Credit value: 15 Semester: A

Overlaps:
- MTH5118 Probability II
- MAS228 Probability II

Essential prerequisites:
- MTH4101 Calculus II

and either of
- MTH4107 Introduction to Probability
- MTH4108 Probability I

Helpful prerequisites:
- MTH4106 Introduction to Statistics

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~ig/MTH5121

Comment: Assessment in 2010–11 was 10% coursework, 10% in-term test, 80% final exam

Syllabus

1. Discrete Methods:
   - Revision of conditional probability and probability generating functions.
   - Computing probabilities by conditioning.

2. Discrete Models:
   - Random Walks: The gambler's ruin problem (probability of bankruptcy and expected duration of the game), random walk on the integers including probability of eventual return to the origin.
   - Branching processes: analysis using generating functions including probability of eventual extinction.

3. Continuous Methods
   - Joint distribution of continuous random variables (examples including bivariate Normal distribution)
4. Continuous Models

- Poisson process: definition via Poisson distribution, arrival times and interarrival times as examples of jointly distributed random variables.

5. Limit Theorems

- Markov's inequality, Chebyshev's inequality, the Law of Large Numbers.
- Statement of the Central Limit Theorem and application to the random walk on the integers.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5121

Learning resources

Main text:
- S Ross: A First Course in Probability, Pearson Education (2001)

MTH6141 Random Processes

Description

This is an advanced module in probability, introducing various probability models used in physical and life sciences and economics. It serves as an introduction to stochastic modelling and stochastic processes. It covers discrete time processes including Markov chains and random walks, and continuous time processes such as Poisson processes, birth-death processes and queueing systems. It builds on previous probability modules but needs no background in statistics; some experience of linear algebra is also desirable.

Details

Organiser: Professor M Jerrum

Level: 6  Credit value: 15  Semester: B

Overlaps:
- MAS338 Probability III
- MTH6130 Probability III

Essential prerequisites:

Either of
- MTH5118 Probability II
- MTH5121 Probability Models

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~mj/MTH6141

Comment: Replaces MTH6130 Probability III from 2011–12

Syllabus

Discrete time processes [6 weeks]

1. Discrete Markov chains (definition and examples). Description by transition graph and transition matrix.
2. Markov chains with absorbing states (probability of absorption in a given state, expected time to absorption via first-step analysis).
4. Recurrence and transience.
5. Extended examples: Random walks on a finite interval with absorbing and reflecting boundaries, Random walks on infinite intervals, Branching processes.

Continuous time processes [5 weeks]

Queueing systems (notation and examples). Relation of M/M/t queue to birth-death process. Brief discussion of M/G/1 and G/M/1 queues.

Learning outcomes

At the end of this module students will be able to:

- Specify a given discrete time Markov chain in terms of a transition matrix and a transition diagram.
- Calculate n-step transition probabilities.
- Apply the method of first step analysis to calculate absorption probabilities and mean time to absorption for an absorbing discrete time Markov chain.
- Calculate equilibrium and limiting distributions for finite state discrete time Markov chains, and explain the relation between them for irreducible and regular chains.
- Assess whether states are recurrent or transient in simple cases.
- State and apply the definition of the Poisson process, in both infinitesimal form and otherwise.
- State and apply the definition of, and the relation between, the waiting times and sojourn times for the Poisson process and the general birth process.
- For a birth-death process, derive and apply the backwards and forwards equations. Find the equilibrium distribution. (Note: birth processes are a special case of this).
- Explain the standard notation for queuing systems.
- Explain the relation between M/M/k queues and birth-death processes.

Learning resources

Main text:

- N M Taylor and S Karlin, An Introduction to Stochastic Modeling

MTH6132 Relativity

Description

This module is an introduction to Einstein's theories of special and general relativity. The first part of the module deals with special relativity, and is mainly about the strange dynamics that happen at speeds comparable to the speed of light. The second part develops the mathematical machinery needed to study the curvature of space-time and the subtle effects of gravity; this is the general theory of relativity. The third part deals with various consequences of the theory, and will touch upon topics like black holes and the big bang.

Details

Organiser: Dr J A Valiente-Kroon
Level: 6  Credit value: 15  Semester: A
Overlaps:
- MAS322 Relativity

Essential prerequisites:
- MTH4101 Calculus II
- MTH4102 Differential Equations
- MTH5112 Linear Algebra I

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~jav/MTH6132

Comment: Assessment in 2010–11 was 10% coursework, 90% final exam

Syllabus

2. Vectors in Special Relativity: 4-vectors and the Lorentz transformation matrix 4-velocity, 4-momentum, 4-acceleration. Relativistic dynamics and collisions. Optics: redshift and aberration
Curvature and geodesic deviation. Einstein's field equations.


Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6132

Learning resources

Main texts:
- M V Berry, Principle of Cosmology and Gravitation (CUP) [Elementary]
- R d'Inverno, Introducing Einstein's Relativity (Clarendon Press, Oxford) [Intermediate]
- B F Schutz, A First Course in General Relativity (CUP) [Intermediate]
- L Ryder, General Relativity (CUP) [Intermediate-Advanced]
- W Rindler, Essential Relativity: Special, General and Cosmological (Springer-Verlag) [Intermediate]
- A Einstein, The Principle of Relativity (Dover) [Classical]

MTH720U Relativity and Gravitation

Description

Details
Organiser: Dr A G Polnarev
Level: 7  Credit value: 15  Semester: A
Overlaps:
- MAS412 Relativity and Gravitation

Essential prerequisites:
Either of
- MTH6132 Relativity
- MAS322 Relativity

Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~agp/MTH720U
Comment: Not offered 2010–11

Syllabus
1. Introduction to general relativity.
3. Physical aspects of strong gravitational fields around black holes.
4. Generation, propagation and detection of gravitational waves.
5. Weak general relativistic effects in the solar system and binary pulsars.
6. Alternative theories of gravity and experimental tests of general relativity.

Learning outcomes
Not yet available

MTH724U Solar System

Description
As the planetary system most familiar to us, the Solar System presents the best opportunity to study questions about the origin of life and how enormous complexity arise from simple physical systems in general. This course surveys the physical and dynamical properties of the Solar System. It focuses on the formation, evolution, structure, and interaction of the Sun, planets, satellites, rings, asteroids, and comets. The course applies basic physical and mathematical principles needed for the study, such as fluid dynamics, electrodynamics, orbital dynamics, solid
mechanics, and elementary differential equations. However, prior knowledge in these topics is not needed, as they will be introduced as required. The course will also include discussions of very recent, exciting developments in the formation of planetary and satellite systems and extrasolar planets (planetary migration, giant impacts, and exoplanetary atmospheres).

**Details**

**Organiser:** Dr J Cho

**Level:** 7  **Credit value:** 15  **Semester:** A

**Overlaps:**
- MAS423 Solar System

**Essential prerequisites:**
- MTH5106 Dynamics of Physical Systems

**Assessment:** 100% final exam

**Organiser's module website:** [http://www.maths.qmul.ac.uk/~cho/ASTM001](http://www.maths.qmul.ac.uk/~cho/ASTM001)

**Syllabus**

The material presented in this module will be chosen from the following:

1. General overview/survey
2. Fundamentals: two-body problem, continuum equations
3. Terrestrial planets: interiors, atmospheres
4. Giant planets: interiors, atmospheres
5. Satellites: three-body problem, tides
6. Resonances and rings
7. Solar nebula and planet formation
8. Asteroids, comets and impacts

**Learning outcomes**

Not yet available

**Learning resources**

**Main texts:**
- I de Peter & J J Lissauer, Planetary Sciences (Cambridge University Press)
- C D Murray & S F Dermott, Solar System Dynamics (Cambridge)

**Other texts:**

**MTH5122 Statistical Methods**

**Description**

This module develops some of the ideas first introduced in Introduction to Statistics. It begins by covering some of the essential theoretical notions required, such as covariance, correlation and independence of random variables. The majority of the material covers different types of statistical tests: how to use them and when to use them. This material is essential for applications of statistics in psychology, the life or physical sciences, business or economics. It is also required for further study of statistics.

**Details**

**Organiser:** Dr L Pettit

**Level:** 5  **Credit value:** 15  **Semester:** A

**Overlaps:**
- MTH5118 Probability II
- MAS228 Probability II
- MTH736U Mathematical Statistics
Essential prerequisites:
- MTH4106 Introduction to Statistics

Assessment: 10% mid-term test, 90% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~pettit/MTH5122

Comment: Assessment in 2010–11 was 20% coursework, including any in-term tests, 80% final exam

Syllabus

5. F test, 2-sample t test and corresponding confidence intervals.
6. Approximate 2-sample test when variances are unequal. Matched pairs t test, discussion about design and blocking and when to use which test.
8. Test of 2 proportions and relationship to contingency tables. Approximate test for correlation coefficient.
10. Central limit theorem (by way of mgf).

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5122

MTH5120 Statistical Modelling I

Description
This is a first module on linear models and it concentrates on modelling the relationship between a continuous response variable and one or more continuous explanatory variables. Linear models are very widely used in almost every field of business, economics, science and industry where quantitative data are collected. They are also the basis for several more advanced statistical techniques covered in level-6 modules. This module is concerned with both the theory and applications of linear models and covers problems of estimation, inference and interpretation. Graphical methods for model checking will be discussed and various model selection techniques introduced. Computer practical sessions, in which the Minitab statistical package is used to perform the necessary computations and on which the continuous assessment is based, form an integral part of the module.

Details
Organiser: Dr B Bogacka
Level: 5 Credit value: 15 Semester: B

Overlaps:
- MAS232 Statistical Modelling I

Essential prerequisites:
- MTH5112 Linear Algebra I

and either of
- MTH5118 Probability II
- MTH5122 Statistical Methods

Assessment: 10% coursework. 10% mid-term test, 80% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~bb/MTH5120

Syllabus
The techniques covered will be applied to data from various areas of business, economics, science and industry.

1. Relationships among variables and basic concepts of statistical modelling, response and explanatory variables.
2. The Normal-linear model: definition, matrix form, simple, multiple and polynomial regression models.
5. Assessing fitted models: analysis of variance, $R^2$, lack of fit, residuals and model checking, outliers.
7. Inference: confidence intervals for parameters and mean response, testing for parameters and mean response.
8. Uses of linear models – prediction, control, optimisation.
10. Use of Minitab to apply the theory to practical data analysis.

**Learning outcomes**

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH5120

**Learning resources**

Main text:
- B Abraham and J Ledolter, Introduction to Regression Modeling (Duxbury)
- Lindley/Scott, New Cambridge Elementary Statistical Tables (CUP)

Other texts:
- Draper & Smith, Applied Regression Analysis (Wiley)
- Sen & Srivastava, Regression Analysis (Springer)

**MTH6134 Statistical Modelling II**

**Description**

This is the part of linear models often called analysis of variance. It concentrates on models whose explanatory variables are qualitative. These methods are used in almost all areas of business, economics, science and industry where qualitative and quantitative data are collected.

**Details**

Organiser: Dr M Arephin
Level: 6  Credit value: 15  Semester: A

Overlaps:
- MAS339 Statistical Modelling II

Essential prerequisites:
- MTH5120 Statistical Modelling I

Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~arephin/MTH6134
Comment: Assessment in 2010–11 was 20% coursework, 80% final exam

**Syllabus**

Extended use of the comprehensive statistical package GenStat is developed as it is required in the module. The methods introduced are applied to data from various applications in business, economics, science and industry.

1. Qualitative explanatory variables – models, factors, main effects and interactions.
2. Indicator variables – representation as linear regression models.
5. Nested, crossed and general structures.

**Learning outcomes**

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6134

**Learning resources**
MTH6136 Statistical Theory

Description
The theory developed will be used to justify the methods introduced in Introduction to Statistics and will be used to analyse data from a variety of applications. The module will cover estimation, methods of estimation, confidence intervals, and testing.

Details
Organiser: Dr D S Coad
Level: 6  Credit value: 15  Semester: B

Overlaps:
- MAS230 Fundamentals of Statistics II

Essential prerequisites:
Either of
- MTH5118 Probability II
- MTH5122 Statistical Methods

Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~coad/MTH6136

Comment: Assessment in 2010–11 was 10% in-term, 90% final exam

Syllabus
The theory developed will be used to justify the methods introduced in MTH4106 Introduction to Statistics and will be used to analyse data from a variety of applications.

2. Methods of estimation: method of moments, maximum likelihood, least squares, properties of estimators obtained from these methods, asymptotic properties of MLEs.
3. Confidence intervals: methods of obtaining CIs using pivots, likelihood CIs.

Learning outcomes
http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6136

Learning resources

Recommended:

Other texts:

MTH725U Stellar Structure and Evolution
Description
Stars are important constituents of the universe. This course starts from well known physical phenomena such as gravity, mass conservation, pressure balance, radiative transfer of energy and energy generation from the conversion of hydrogen to helium. From these, it deduces stellar properties that can be observed (that is, luminosity and effective temperature or their equivalents such as magnitude and colour) and compares the theoretical with the actual. In general good agreement is obtained but with a few discrepancies so that for a few classes of stars, other physical effects such as convection, gravitational energy generation and degeneracy pressure have to be included. This allows an understanding of pre-main sequence and dwarf stages of evolution of stars, as well as the helium flash and supernova stages.

Details
Organiser: Dr S V Vorontsov

Level: 7  Credit value: 15  Semester: A

Overlaps:
- MAS415 Stellar Structure and Evolution

Essential prerequisites:
- MTH5102 Calculus III
- MTH6129 Oscillations, Waves and Patterns

Assessment: 100% final exam

Organiser’s module website: http://www.maths.qmul.ac.uk/~svv/MTH725U

Syllabus
1. Observational properties of stars, the H-R diagram, binary stars, clusters, solar and stellar oscillations.
2. Physical properties of stellar interiors: virial theorem, gravitational energy, radiative transfer, opacity and equation of state, convection, nuclear reactions.
3. Equations of stellar structure and evolution. Order of magnitude estimates, simple stellar models. Convective cores and envelopes, the Cowling model, models of the Sun, acoustic models, massive stars, small mass stars.
4. Pre-main sequence evolution, evolution on the main sequence, post main sequence evolution. Degeneracy, models of white dwarfs, models of red giants. Late stages of stellar evolution, nucleosynthesis.

The module includes some exposure to simple numerical techniques of stellar structure and evolution; computer codes in Fortran.

Learning outcomes
Not yet available

MTH726U The Galaxy

Description
The module considers in detail the basic physical processes that operate in galaxies, using our own Galaxy as a detailed example. This includes the dynamics and interactions of stars, and how their motions can be described mathematically. The interstellar medium is described and models are used to represent how the abundances of chemical elements have changed during the lifetime of the Galaxy. Dark matter can be studied using rotation curves of galaxies, and through the way that gravitational lensing by dark matter affects light. The various topics are then put together to provide an understanding of how the galaxies formed.

Details
Organiser: Dr W J Sutherland

Level: 7  Credit value: 15  Semester: B

Overlaps:
- MAS430 The Galaxy

Essential prerequisites:
- MTH5102 Calculus III
Assessment: 100% final exam

Organiser's module website: http://www.maths.qmul.ac.uk/~wjs/MTH726U

Syllabus

1. Introduction: galaxy types, descriptive formation and dynamics.
2. Stellar dynamics: virial theorem, dynamical and relaxation times, collisionless Boltzmann equation, orbits, simple distribution functions, Jeans equations.
3. The interstellar medium: emission processes from gas and dust (qualitative only), models for chemical enrichment.
4. Dark matter – rotation curves: bulge, disk, and halo contributions.
5. Dark matter – gravitational lensing: basic lensing theory, microlensing optical depth.
6. The Milky Way: mass via the timing argument, solar neighbourhood kinematics, the bulge, the Sgr dwarf.

Learning outcomes

Not yet available

MTH6138 Third-Year Project

Description

This module allows third-year undergraduates with suitable background to take a project, including one of the 30-credit MSci projects in a simplified form as a 15-credit project, although some MSci projects may not be available as third-year projects. The list of potential MSci projects and supervisors is available on the School of Mathematical Sciences website. You will be accepted onto this module only after agreement between your adviser, the module organiser and the project supervisor.

Details

Organiser: Professor L H Soicher
Level: 6  Credit value: 15  Semester: A or B
Overlaps:
- MAS342 Third-Year Project

Essential prerequisites:
- You should begin preparation over the summer and before registering you must consult the module organiser.

Helpful prerequisites:
- MTH5117 Mathematical Writing

Restrictions: You will not normally be allowed to take this module together with another project module. Not open to Associate Students.

Assessment: Written report, presentation and (possibly) oral exam

Organiser's module website: http://www.maths.qmul.ac.uk/~leonard/MTH6138

Syllabus

A project in any area of mathematics, including astronomy and computing, which is offered in both of semesters 5 and 6. It may be a simplified version of an MSci project, although some MSci projects may not be available as third-year projects. The project will be assessed primarily by a written report and, at the examiners' discretion, an oral examination, but also by a presentation of about 20 minutes in duration, to be given towards the end of semester 6. The contribution of the presentation will be on a sliding scale that will never decrease the project mark by more than 10% or increase it by more than 20%, and provided you make a reasonable attempt at giving a presentation it will not decrease your project mark.

Your report must present the study of some mathematical topic at third-year undergraduate level and must be your own work in the sense that it gives an original account of the material, but it need not contain new mathematical results. It is sufficient to read several sources on the project topic and then write about this topic in your own words. The length should be about 4000 words; if it is less than 3500 or more than 5000 words you may lose marks.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6138

MTH6139 Time Series
Description

A time series is a collection of observations made sequentially, usually in time. This kind of data arises in a large number of disciplines ranging from economics and business to astrophysics and biology. This module introduces the theory, methods and applications of analysing time series data.

Details

Organiser: Dr D S Coad

Level: 6  Credit value: 15  Semester: A

Overlaps:
- MAS328 Time Series
- ECN323 Economic Forecasting

Essential prerequisites:
- MTH5120 Statistical Modelling I

and either of
- MTH5118 Probability II
- MTH5121 Probability Models

Assessment: 20% two in-term tests, 80% final exam

Organiser’s module website: http://www.maths.qmul.ac.uk/~coad/MTH6139

Syllabus

The course includes time series analysis using MINITAB. The methods developed are applied to data arising in applications in economics, business, science and industry.

1. General introduction and motivation.
4. Time series as a stationary stochastic process.
5. Modelling of time series in the time domain. Development of AR(p) and MA(q) models in general and their detailed study for the case of p = q = 1.
6. ARMA models.
7. Model identification using the ACF and PACF.
8. Estimation of parameters by moments, least squares and maximum likelihood methods.
9. Forecasting by least squares and conditional expectations.
10. ARIMA models.

Learning outcomes

http://www.maths.qmul.ac.uk/undergraduate/modules/learning-outcomes#MTH6139

Learning resources

Recommended:

Other texts:

MTH734U Topics in Probability and Stochastic Processes

Description

This module aims to present some advanced probabilistic concepts and demonstrate their application to stochastic modelling of real-world situations. The topics covered vary from year to year but may include, for example, limit theorems, renewal theory, and continuous-time Markov processes. In addition to exposure to proofs and theoretical material, students develop practical skills through a large number of problems and
Details
Organiser: Dr D Stark
Level: 7  Credit value: 15  Semester: B
Overlaps:
- MAS420 Topics in Probability and Stochastic Processes
Essential prerequisites:
Either of
- MTH5118 Probability II
- MTH5121 Probability Models
Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~dstark/MTH734U

Syllabus
Topics will be chosen from the following list:

1. Borel-Cantelli lemma, Kolmogorov's inequalities, strong law of large numbers.
2. Weak convergence of distributions. The Central Limit Theorem.
3. Recurrent events and renewal theory.
4. Further topics in random walks.
5. General theory of Markov chains. Classification of states and ergodic properties.

Learning outcomes
Not yet available

Learning resources
Main texts:
- W Feller, An Introduction to Probability Theory and its Applications I (Wiley)

MTH739U Topics in Scientific Computing

Description
This module focuses on the use of computers for solving applied mathematical problems. Its aim is to provide students with proper computational tools to solve problems they are likely to encounter while doing their MSc or MSci, and to provide them with a sound understanding of a programming language used in applied sciences. The topics covered will depend on the module organiser's expertise, with a view to emphasize applications rather than theory.

Details
Organiser: Dr A Baule
Level: 7  Credit value: 15  Semester: B
Overlaps: None
Prerequisites: Appropriate level-6 mathematical background; consult the module organiser for details
Assessment: 50% coursework, 50% project
Organiser's module website: http://www.maths.qmul.ac.uk/~baule/MTH739U

Syllabus
1. Introduction to programming: Loops; If statements; procedures; input/output; recursion; program structure
2. Numerical solution of ordinary differential equations: Euler scheme; higher-order schemes; Runge-Kutta integrator; applications
3. Random number generation: random vs pseudo-random numbers; linear congruent systems; transformation of random variables; normal
Variates; applications
4. Monte Carlo methods: direct sampling; importance sampling; Markov chains; applications
5. Simulation of stochastic processes: Random walks; Markov chains; continuous-time limit; Brownian motion; stochastic differential equations; applications

Learning outcomes
At the end of this module students will be able to:

- Use a programming language used in applied sciences (e.g., C or Matlab)
- Use the basic structures of programming (loops, conditionals, recursion, procedures)
- Know how to write efficient programs to solve mathematical problems at pre-research level
- Identify and explain essential simulations methods used in science (e.g., numerical integration, Monte Carlo methods)
- Identify limitations and errors in algorithms and programs
- Identify examples of computers for solving pure and applied mathematical problems
- Investigate stochastic processes by simulating them
- Write and describe a program for solving a suitably advanced mathematical or scientific problem, as part of a semester project

Learning resources


MTH732U Topology

Description
Topology is the study of properties of shape which remain the same when pulled, pushed or squeezed by a continuous process of deformation. For example, the property of a space being connected or a surface having a hole is a topological property. In this module we start with general point set topology and formal definitions and move on to study powerful algebraic invariants such as the fundamental group. Topology allows access to many exciting areas of modern mathematics.

Details
Organiser: Professor I Goldsheid
Level: 7 Credit value: 15 Semester: B
Overlaps:
- MAS329 Topology

Essential prerequisites:
- MTH4104 Introduction to Algebra

and
- MTH6126 Metric Spaces

Helpful prerequisites:
- MTH5100 Algebraic Structures I

Assessment: 100% final exam
Organiser's module website: http://www.maths.qmul.ac.uk/~ig/MTH732U

Syllabus

1. Topological spaces: examples including discrete, indiscrete, metric and co-finite topologies.
2. Continuity and convergence, homeomorphisms, topological and non-topological properties.
3. Paths and path connectedness.
7. The fundamental group, definition and elementary properties. Fundamental group of a circle. Path and homotopy lifting (proofs...
Learning outcomes

Know the definition and properties of a metric space and understand the standard examples of metric spaces. Know the definition of a topological space in general and understand specific examples. Know the definition and uses of equivalent metrics. Know and be able to use the definition of a continuous map between topological spaces. Know the definition of the relative (subspace) topology and the definition of homeomorphism. Know the definition of closed set and related concepts. Know the definition and use of convergent sequence. Know the definition and properties of Hausdorff space. Know the definition and properties of compact space, and the statement of the Heine-Borel Theorem. Know the definition and properties of connectedness and paths. Know the definition of quotient space and quotient map, and be able to describe some examples. Know the definition of path homotopy, and be able to give a summary of the construction of the fundamental group.

Learning resources

Main texts:
- B Mendelson, Introduction to topology (Dover Publications)
- W A Sutherland, Introduction to metric and topological spaces (CUP)