FMS1201M Freshmen Seminar: Is Computer Science Science?
Modular Credits: 4
Workload: 0-3-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

This seminar seeks to help the freshmen to gain a fundamental understanding of Computer Science and a broader perspective of how it relates to other sciences. The major topics include the similarity and differences between Computer Science and the traditional sciences (Physics, Biology, Mathematics, etc.), the objective and methodology in Science, and the scientific aspects of computation (hardware, software, systems, etc.).

FMS1202M Freshmen Seminar: Mathematics in Science, Technology and Society
Modular Credits: 4
Workload: 0-3-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

Mathematics is the best known but least understood subject. It plays a fundamental role in the development of science, technology and society but it has received little commercial recognition and is often perceived as not useful in life. The seminar will expose students to various views about the nature of mathematics, the enterprise called mathematics and the role of mathematics in modern science, technology and society. Students will also learn a high-level mathematical software such as Maple or Mathematica and use them in conjunction with mathematics for modelling, computation and visualization of specific applications in modern science and technology. The mathematics will include, but not confine to, fast Fourier transform, scale-space representation, discrete wavelet transform, Bezier and B-spline curves and surfaces. The mathematics will be mostly algorithmic and discrete in the beginning and will be introduced gently at a level suitable to the students’ background, which may be different for different students.

FMS1203M Freshmen Seminar: The Mathematics of Infinity
Modular Credits: 4
Workload: 0-3-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

The concept of infinity has fascinated mankind for thousands of years. It appears in writings, paintings, religion and science and many other human creations. This seminar will focus on topics related to the mathematics of infinity. The significance of infinity and the role played by it in mathematical thoughts will be studied and discussed.
FMS1204M Freshmen Seminar: Appreciation of Basic Results in Mathematics

Modular Credits: 4
Workload: 0-3-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

Mathematical results are crystallisations of the collective wisdom of mankind and have their historical backgrounds, significances, impacts and applications. This seminar module provides a platform for freshmen to discuss these aspects of some selected mathematical results and principles. Amongst the topics that would be discussed are:

- Prime numbers and the Fundamental Theorem of Arithmetic
- Complex numbers and the Fundamental Theorem of Algebra
- Fibonacci sequence
- Golden section
- Catalan numbers
- Euler’s formula \( v - e + f = 2 \) and Pick’s Theorem
- The Pigeonhole Principle
- Mathematical Induction
- The identity \( e^{i\pi} = -1 \)
- Inequalities, arithmetic mean, geometric mean and harmonic mean
- Modular arithmetic, congruence and Fermat’s Little Theorem
- Counting Principles and Binomial coefficients
- The Fundamental Theorem of Calculus
- L’Hopital’s Rule

FMS1205M Freshmen Seminar: Analogy & Intuition in Mathematics

Modular Credits: 4
Workload: 0-3-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

The development of mathematical concepts and theories is often influenced by an intuition acquired from physical experience and by analogy with various areas of scientific and mathematical knowledge. Analogy is a powerful force in preparing, if not predicting, new concepts while an experience-based intuition can sometimes be an obstacle. The objective of this seminar module is to present case studies of the creative role of analogy in mathematics and of the ground-breaking importance of "counter-intuition" in modern mathematics. A wealth of examples of both can be found in geometry, number theory, analysis, algebra, logic, set theory and theoretical computer science. Students of this module are expected to source for relevant material in books, journals and even the internet under the guidance of the lecturer. The emphasis, however, will be on the spirit of the mathematical enterprise rather than on the technical mastery. To illustrate the use of analogy and intuition in problem solving, some puzzles and elementary problems will be posed in class for attempt and discussion.
FMS1206M Freshmen Seminar: Is Mathematics Science?
Modular Credits: 4  
Workload: 0-3-0-3-4  
Prerequisite(s): Nil  
Preclusion(s): Nil  
Cross-listing(s): Nil  
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

This seminar seeks to help the freshmen to gain a fundamental understanding of Mathematics and a broader perspective of how it relates to other sciences. The major topics include the similarity and differences between Mathematics and the other sciences (Astronomy, Biology, Computer Science, etc.), the objectives and methodology in Science, and the role of Mathematics in Science.

FMS1207M Freshmen Seminar: Mathematics and Computer Science
Modular Credits: 4  
Workload: 0-3-0-3-4  
Prerequisite(s): Nil  
Preclusion(s): Nil  
Cross-listing(s): Nil  
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

Mathematics plays an important role in computing: Boolean algebra and basic arithmetic is used for building the basic elements of computers, mathematical logic is used to describe the theoretical foundations of computer science, linear algebra and geometry are used when modelling of physical environments and virtual realities for animated movies and video games; game theory is employed when programming strategic games like chess and go on computers. The seminar gives an overview of the role of mathematics in computer science and the history of the two disciplines.

FMS1208M Freshmen Seminar: Space, Time and the Universe
Modular Credits: 4  
Workload: 0-3-0-3-4  
Prerequisite(s): Nil  
Preclusion(s): Nil  
Cross-listing(s): Nil  
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

This seminar module traces the developments in ideas of space and time, with particular references to theoretical and observational cosmology, starting from Newtonian mechanics, Einstein’s relativity, Hubble’s observations, the Big Bang, black holes, dark energy to recent ideas in the origin and fate of the Universe. Reading this seminar, students will develop an appreciation of the motivation behind physical theories, the status of these theories and their relationship to observational data. This seminar will also discuss the connection of contemporary cosmology with the broader society, its public understanding and the need for scientific literacy.
FMS1209M Freshmen Seminar: Philosophy of Mathematics
Modular Credits: 4
Workload: 0-3-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

Compared to other branches of natural sciences, mathematics arguably raised more philosophical questions. Since ancient times, philosophers and mathematicians have been debating questions about the nature of mathematics. In this seminar, we join their debate and look at questions about the nature of mathematics related to both ontology and epistemology. For example, What is the nature of mathematical truth? Do mathematical objects and facts exist independently of human consciousness? Are theorems invented or discovered? How does one explain the unreasonable usefulness of mathematics? Do we really need more and more abstract mathematical concepts?

FMS1210M Freshmen Seminar: Turning Points in the History of Mathematics
Modular Credits: 4
Workload: 0-3-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

Mathematics is probably the oldest intellectual enterprise of humanity. From its earliest beginnings in various ancient cultures, it has developed into the language of science and of a large part of rational thinking. How mathematics has developed into its present stage raises some intriguing and fascinating questions. Is its development an inevitable outcome of human evolution? Are there turning points in the history of mathematics that are crucial for its development? How has the development of mathematics been affected by other areas of human activity?

FMS1211M Freshmen Seminar: Mathematics in Modern Technology
Modular Credits: 4
Workload: 0-3-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)

Even if you are not a fan of mathematics, it is hard to argue that it has not been a vital factor in modern technology. Mathematics has given rise to computers and allowed us to decode the secrets of the DNA and transmit information safely over internet.
This seminar module provides a platform for Freshmen to discuss the impact of mathematics on modern technology.

**FMS1212M Freshmen Seminar: Uncovering the Magic in Magic Squares and Magic Graphs**

Modular Credits: 4  
Workload: 0-3-0-3-4  
Prerequisite(s): Nil  
Preclusion(s): Nil  
Cross-listing(s): Nil  
*(Only newly matriculated Science students are allowed to read Freshmen Seminar in their first two semesters in NUS)*

Magic squares is a simple concept that has been around for thousands of years. Mathematicians have long been fascinated by the mesmerising patterns that they produce, and thus it is not surprising to find many amazing variations on magic squares. A graph labelling is an assignment of integers to the vertices or edges, or both, subject to certain conditions. The ideas of magic squares have also been expanded to magic graphs through graph labelling. In this module, students will uncover the amazing mathematical ideas and patterns in magic squares and its variations as well as magic graphs.

**GEK1505 Living with Mathematics (for AY2014/15 and before cohorts)**

Modular Credits: 4  
Workload: 3-1-0-3-3  
Prerequisite(s): Nil  
Preclusion(s): GEH1036  
Cross-listing(s): Nil

The objective of this course is to exhibit some simple mathematical ideas that permeate a modern society and to show how a reasonably numerate person can use these ideas in everyday life and, in the process, gain an appreciation of the beauty and power of mathematical ideas. For example, we will learn some counting methods that can be applied to the enumeration of bus routes in a model of a grid system of roads in a city. We will also investigate some basic properties of graphs, which are mathematical structures used to model relationships between people in social networks, groups, organizations, computers, URLs etc. Transmission of digital information and signals is now an integral part of modern society. We will look at questions like: How do we encode information so that certain errors in transmission can be detected, or even corrected? How do we check that a given sequence of numbers is a proper International Standard Book Number (ISBN)? How do we encrypt sensitive information like credit card numbers using properties of prime numbers? Finally, we will examine some basic ideas in probability which are often at the basis for making decisions and judgement in the real world with random outcomes and measurements.
GEH1036 Living with Mathematics (for AY2015/16 and later cohorts)
Modular Credits: 4
Workload: 3-1-0-3-3
Prerequisite(s): Nil
Preclusion(s): GEK1505
Cross-listing(s): Nil

The objective of this course is to exhibit some simple mathematical ideas that permeate a modern society and to show how a reasonably numerate person can use these ideas in everyday life and, in the process, gain an appreciation of the beauty and power of mathematical ideas. For example, we will learn some counting methods that can be applied to the enumeration of bus routes in a model of a grid system of roads in a city. We will also investigate some basic properties of graphs, which are mathematical structures used to model relationships between people in social networks, groups, organizations, computers, URLs etc. Transmission of digital information and signals is now an integral part of modern society. We will look at questions like: How do we encode information so that certain errors in transmission can be detected, or even corrected? How do we check that a given sequence of numbers is a proper International Standard Book Number (ISBN)? How do we encrypt sensitive information like credit card numbers using properties of prime numbers? Finally, we will examine some basic ideas in probability which are often at the basis for making decisions and judgement in the real world with random outcomes and measurements.

GEK1517 Mathematical Thinking (for AY2014/15 and before cohorts)
Modular Credits: 4
Workload: 3-1-0-2-4
Prerequisite(s): Nil
Preclusion(s): GEK1505
Cross-listing(s): Nil

The objectives of this course are to introduce basic notions in mathematics and to develop thinking skills in terms of ideas and intuition. Illustrated by simple examples and with wonderful developments, the course is especially designed to inspire students to apply imagination and creativity in understanding mathematics. For example, how do we recognise simple number patterns and geometric figures, guess a formula, and justify its validity? Does intuitive idea always work? Why do we need axioms and what are undefined terms? What are analogies and generalizations in mathematics? How do algorithms such as the algorithm of finding the greatest common divisor of two numbers come about in terms of thinking process? What do we think of mathematics? The course also includes a discussion on some famous incidents of pleasant surprises and discoveries in the scientific and mathematical communities.

GET1017 Mathematical Thinking (for AY2015/16 and later cohorts)
Modular Credits: 4
Workload: 3-1-0-2-4
Prerequisite(s): Nil
Preclusion(s): GEK1517
Cross-listing(s): Nil

The objectives of this course are to introduce basic notions in mathematics and to develop thinking skills in terms of ideas and intuition. Illustrated by simple examples and with wonderful developments, the course is especially designed to inspire students to apply imagination and creativity in understanding mathematics. For example, how do we recognise simple number patterns and geometric figures, guess a formula, and justify its validity? Does intuitive idea always work? Why do we need axioms and what are undefined terms? What are analogies and generalizations in mathematics? How do algorithms such as the algorithm of finding the greatest common divisor of two numbers come about in terms of thinking process? What do we think of mathematics? The course also includes a discussion on some famous incidents of pleasant surprises and discoveries in the scientific and mathematical communities.
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**GEK1531 Cyber Security (for AY2014/15 and before cohorts)**
Modular Credits: 4  
Workload: 3-0-0-4-3  
Prerequisite(s): Nil  
Preclusion(s): GET1004  
Cross-listing(s): Nil

The internet has become the most widely-used medium for commerce and communication as its infrastructure can be quickly and easily set up to link to the worldwide network and access information globally. Its growth over the last few years has been phenomenal. With these activities, countries are beginning to recognise that this new technology can not only expand the reach and power of traditional crimes, but also breed new forms of criminal activity. On the successful completion of this module, students should gain sufficient baseline knowledge to be able to identify, assess, and respond to a variety of cybercrime scenarios, including industrial espionage, cyber-terrorism, communications eavesdropping, computer hacking, software viruses, denial-of-service, destruction and modification of data, distortion and fabrication of information, forgery, control and disruption of information. Students will also learn about countermeasures, including authentication, encryption, auditing, monitoring, technology risk management, intrusion detection, and firewalls, and the limitations of these countermeasures. Finally, students will examine how Singapore and international laws deal with various computer-related crimes.

**GET1004 Cyber Security (for AY2015/16 and later cohorts)**
Modular Credits: 4  
Workload: 3-0-0-4-3  
Prerequisite(s): Nil  
Preclusion(s): GEK1531  
Cross-listing(s): Nil

The internet has become the most widely-used medium for commerce and communication as its infrastructure can be quickly and easily set up to link to the worldwide network and access information globally. Its growth over the last few years has been phenomenal. With these activities, countries are beginning to recognise that this new technology can not only expand the reach and power of traditional crimes, but also breed new forms of criminal activity. On the successful completion of this module, students should gain sufficient baseline knowledge to be able to identify, assess, and respond to a variety of cybercrime scenarios, including industrial espionage, cyber-terrorism, communications eavesdropping, computer hacking, software viruses, denial-of-service, destruction and modification of data, distortion and fabrication of information, forgery, control and disruption of information. Students will also learn about countermeasures, including authentication, encryption, auditing, monitoring, technology risk management, intrusion detection, and firewalls, and the limitations of these countermeasures. Finally, students will examine how Singapore and international laws deal with various computer-related crimes.
GEK1544 The Mathematics of Games (for AY2014/15 and before cohorts)
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): Nil
Preclusion(s): GET1018
Cross-listing(s): Nil

Games being a form of human activities since antiquity are often played with strategies that require critical thinking and decision making. Many of the number games like the game of nim have a rich mathematics favour. Real life social games contain combinatorial and probabilistic strategies. Simple economic activities can also be modelled in terms of games. In this module, selected real-life social games are discussed and treated in ways that bring out their mathematical creativity. The objective is to let students gain an appreciation of mathematics, its beauty and applications through the discussion of some of these games. In particular, we give an introduction of elementary non-zero sum and non-cooperative game as developed by von Neumann and Nash.

GET1018 The Mathematics of Games (for AY2015/16 and later cohorts)
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): Nil
Preclusion(s): GEK1544
Cross-listing(s): Nil

Games being a form of human activities since antiquity are often played with strategies that require critical thinking and decision making. Many of the number games like the game of nim have a rich mathematics favour. Real life social games contain combinatorial and probabilistic strategies. Simple economic activities can also be modelled in terms of games. In this module, selected real-life social games are discussed and treated in ways that bring out their mathematical creativity. The objective is to let students gain an appreciation of mathematics, its beauty and applications through the discussion of some of these games. In particular, we give an introduction of elementary non-zero sum and non-cooperative game as developed by von Neumann and Nash.

MA1100 Fundamental Concepts of Mathematics
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): GCE ‘A’ Level or H2 Mathematics or equivalent or [GM1101 and GM1102] or MA1301 or MA1301FC or MA1301X
Preclusion(s): MA1100S, GM1308, CS1231, CS1231S, CS1301, EEE students, CEG students, CPE students, MPE students, COM students, CEC students
Cross-listing(s): Nil

This module introduces the language, notions, and methods upon which a sound education in mathematics at the university level is built. Students are exposed to the language of mathematical logic, the idea of rigorous mathematical proofs and fundamental mathematical concepts such as sets, relations and functions. Major topics: Elementary logic, mathematical statements, set operations, relations and functions, equivalence relations, elementary number theory.
MA1101R Linear Algebra I
Modular Credits: 4
Workload: 3-1-1-0-6
Prerequisite(s): GCE ‘A’ Level or H2 Mathematics or MA1301 or MA1301FC or MA1301X
Preclusion(s): EG1401, EG1402, MA1101, MA1311, MA1506, MA1508, FOE students
Cross-listing(s): Nil

This module is a first course in linear algebra. Fundamental concepts of linear algebra will be introduced and investigated in the context of the Euclidean spaces $\mathbb{R}^n$. Proofs of results will be presented in the concrete setting. Students are expected to acquire computational facilities and geometric intuition with regard to vectors and matrices. Some applications will be presented. Major topics: Systems of linear equations, matrices, determinants, Euclidean spaces, linear combinations and linear span, subspaces, linear independence, bases and dimension, rank of a matrix, inner products, eigenvalues and eigenvectors, diagonalisation, linear transformations between Euclidean spaces, applications.

MA1102R Calculus
Modular Credits: 4
Workload: 3-1-1-0-6
Prerequisite(s): GCE ‘A’ Level or H2 Mathematics or MA1301 or MA1301FC or MA1301X
Preclusion(s): EE1401, EE1461, EG1401, EG1402, CE1402, MA1102, MA1312, MA1505, MA1505C, MA1507, MA1521, CEC students, COM students who matriculated on and after 2002 (including poly 2002 intake), FOE students
Cross-listing(s): Nil

This is a course in single-variable calculus. We will introduce precise definitions of limit, continuity, the derivative and the Riemann integral. Students will be exposed to computational techniques and applications of differentiation and integration. This course concludes with an introduction to first order differential equations.

Major topics: Functions, precise definitions of limit and continuity. Definition of the derivative, velocities and the Riemann integral. Students will be exposed to computational techniques and applications of differentiation and integration. This course concludes with an introduction to first order differential equations.

MA1104 Multivariable Calculus (To be offered for the last time in Semester 1, AY2017/2018)
Modular Credits: 4
Workload: 3-1-1-0-6
Prerequisite(s): MA1102 or MA1102R or MA1505 or MA1505C or MA1521 or EE1401 or EE1461 or EG1402
Preclusion(s): MA1104S, MA2207, MA2221, MA2311, MA3208, GM2301, MQ2202, MQ2102, MQ2203, PC1134, PC2201, MA1507, MPE students
Cross-listing(s): Nil

[Items in DARK RED denote changes from this academic year]
This is a module on the calculus of functions of several real variables, applications of which abound in mathematics, the physical sciences and engineering. The aim is for students to acquire computational skills, ability for 2- and 3-D visualisation and to understand conceptually fundamental results such as Green’s Theorem, Stokes’ Theorem and the Divergence Theorem. Major topics: Euclidean distance and elementary topological concepts in R2 and R3, limit and continuity, implicit functions. Partial differentiation, differentiable functions, differentials, chain rules, directional derivatives, gradients, mean value theorem, Taylor’s formula, extreme value theorem, Lagrange multipliers. Multiple integrals and iterated integrals change of order, applications, change of variables in multiple integrals. Line integrals and Green’s theorem. Surface integrals, Stokes’ Theorem, Divergence Theorem.

MA1301 Introductory Mathematics
Modular Credits: 4
Workload: 3-1-0-6
Prerequisite(s): Pass in GCE ‘O’ Level Additional Mathematics or GCE ‘AO’ Levels or H1 Mathematics
Preclusion(s): Those with A-level or H2 passes in Mathematics or who have passed any of the modules MA1101R, MA1102R, MA1301FC, MA1301X, MA1505, MA1506, MA1507, MA1508, MA1521, MA1311, MA1312, MA1421, MPE students
Cross-listing(s): Nil

This module serves as a bridging module for students without 'A'-level mathematics. Its aim is to equip students with appropriate mathematical knowledge and skill so as to prepare them for further study of mathematics-related disciplines. At the end of the course, students are expected to attain a level of proficiency in algebra and calculus equivalent to the GCE Advanced Level. Major topics: Sets, functions and graphs, polynomials and rational functions, inequalities in one variable, logarithmic and exponential functions, trigonometric functions, sequences and series, techniques of differentiation, applications of differentiation, maxima and minima, increasing and decreasing functions, curve sketching, techniques of integration, applications of integration, areas, volumes of solids of revolution, solution of first order ordinary differential equations by separation of variables and by integrating factor, complex numbers, vectors.

MA1301X Introductory Mathematics (only available to RNS men for MOOC teaching)
Modular Credits: 4
Workload: 3-1-0-3-3
Prerequisite(s): Pass in GCE ‘O’ Level Additional Mathematics or GCE ‘AO’ Level or H1 Mathematics
Preclusion(s): Those with A-level or H2 passes in Mathematics
Cross-listing(s): Nil

Modes of Teaching:
Electronic media-based lectures, regular tutorials, Coursera (e.g., lectures, regular tests, Q&A, Coursera, problem-based learning)
MA1311 Matrix Algebra
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): GCE ‘AO’ Levels or H1 Mathematics or MA1301 or MA1301FC or MA1301X
Preclusion(s): MA1101R, MA1506, MA1508, FOE students
Cross-listing(s): Nil

This module introduces the basic concepts in matrix algebra which has applications in science, engineering, statistics, economics and operations research. The main objective is to equip students with the basic skills in computing with real vectors and matrices. Specially designed for students not majoring in mathematics, in particular those who read a minor in mathematics, it is also suitable for students who are keen to pick up mathematical skills that will be useful in their own areas of studies. Major topics: Gaussian elimination, solutions to simultaneous equations, matrices, vectors, special matrices, matrix inverses, linear independence, rank, determinants, vectors in geometry, and cross product, introduction to eigenvalues and eigenvectors.

MA1312 Calculus with Applications
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): GCE ‘AO’ Levels or H1 Mathematics or MA1301 or MA1301FC or MA1301X
Preclusion(s): MA1102R, MA1505, MA1505C, MA1521, FOE students
Cross-listing(s): Nil

This module contains the main ideas of calculus that are often encountered in the formulation and solution of practical problems. The approach of this course is intuitive and heuristic. The objective is to develop a competent working knowledge of the main concepts and methods introduced. This module is also designed for students who intend to do a minor in mathematics or for those who are keen to pick up some mathematical skills that might be useful in their own areas of studies. Major topics: Real numbers and elementary analytic geometry. Functions, limits, continuity and derivative. Trigonometric functions. Applications of the derivative. Optimisation problems. Inverse functions. The indefinite integral. The definite integral. Applications of the definite integral: arc length, volume and surface area of solid of revolution. Logarithmic and exponential functions. Techniques of Integration. Taylor’s Formula. Differential equations. Some applications in Business, Economics and Social Sciences.

MA1421 Basic Applied Mathematics for Sciences
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): GCE ‘AO’ Levels or H1 Mathematics
Preclusion(s): Majors in Mathematics, Applied Mathematics, Quantitative Finance or Statistics, second major in Mathematics, Financial Mathematics or Statistics, students who have passed any of the modules MA1102R, MA1312, MA1505, MA1506, MA1507, MA1521
Cross-listing(s): Nil

The objective of this module is to equip science students with the basic mathematics concepts and techniques required in many scientific disciplines, notably chemistry. Major topics include mathematical fundamentals (basics of calculus, matrix algebra and differential equations), graphical, numerical and statistical methods, and techniques in data processing.
MA1505 Mathematics I
Modular Credits: 4
Workload: 3-2-0-0-5
Prerequisite(s): GCE ‘A’ Level Mathematics or H2 Mathematics or MA1301 or MA1301FC or MA1301X
Preclusion(s): MA1102R, MA1312, MA1507, MA1511, MA1521, MA2311, MA2501, EE1461, PC2174
Cross-listing(s): Nil

This module provides a basic foundation for calculus and its related subjects required by engineering students. The objective is to equip the students with various calculus techniques for their engineering courses. The module emphasises problem solving and mathematical methods in single-variable calculus, sequences and series, multivariate and vector calculus, and partial differential equations.

Topics:
- Sets, functions (up to 2 variables) and graphs (including graph of real valued function on 2 variables), polynomials and rational functions, inequalities in one variable, logarithmic and exponential functions, trigonometric functions, sequences and series.
- Differential calculus of one variable, derivatives, differentiability, rules and properties, differentiation of transcendental functions, higher order derivatives, increments and differentials, differential of arc length, curve sketching, extreme values and points of inflection. Maxima and Minima.
- Integration as antidifferentiation, fundamental theorem of calculus, basic rules of integration, integration of polynomial, trigonometric, exponential and logarithmic functions, inverse functions, integration by substitution, integration by parts.
- Vectors and operations on vectors, lines in R2 and in R3, planes in R3, vector product, projections. Simple vector calculus and its contextualization.
- Operations on complex numbers, geometric representation of complex numbers, De Moivre’s formula, roots of complex numbers.
- Parametric differentiation, implicit differentiation, l’Hopital’s rule, optimization problems, techniques of integration, application to areas and volumes of revolution.
- Sequences and series. Tests of convergence and divergence, power series in one variable, interval of convergence, Maclaurin and Taylor series.
- Differential calculus for functions of several variables. Geometric interpretation, partial derivatives, chain rule, directional derivatives, gradient vector, higher order derivatives, normal lines and tangent planes to surfaces, extrema of functions: second derivative test.
- Multiple integrals. Iterated integrals, double integrals, domains of type A and type B, change of variables formula for polar coordinates, triple integrals for rectangular domains.
- Vector calculus. Curves, tangents and arc length, vector fields, conservative vector fields, divergence and curl, line, surface and volume integrals.

MA1506 Mathematics II
Modular Credits: 4
Workload: 3-1-1-0-6
Prerequisite(s): Read MA1102R or MA1505 or MA1521
Preclusion(s): MA1101R, MA1311, MA2312, MA1508, MA2501, EE1461, PC2174
Cross-listing(s): Nil

This module introduces the basic concepts of developing mathematical models for engineering systems and trains students on techniques in differential equations and linear algebra for solving the resulting equations.
The objective is to provide mathematical foundations for numerical solution of complex engineering problems. This modelling module is to be driven from engineering systems perspective and expose students to methodology to identify appropriate simplifications in system modelling that lead to simplified mathematical description from a more comprehensive one. The module develops methods on first and second order differential equations, linear algebra and Laplace transform based on their applications in engineering systems.

Topics:
- Linear algebra. Matrix algebra, determinants, linear system of equations, matrix inversion, linear dependence and independence of vectors, basis and dimension, orthogonality, rank of a matrix, applications in Markov chains and manufacturing economics, determinant and tensor of stress and strain, component mass balance in a steady-state process.
- Modelling and second order differential equations. Harmonic oscillator, method of undetermined coefficients, forced oscillations, conservation and conversion, RLC, RL, RC circuit modelling, formulation for heat conduction along a bar, static deformation of a beam, mass-spring-damper vibration, Euler beams under static loads leading to a fourth-order ordinary differential equation, dispersed plug flow reactor with first order reaction.
- Linear transformations. Properties of linear transformations, eigenvalues and eigenvectors, diagonalisation, buckling and vibration of beams.
- Linear systems of differential equations. Theory of linear DE systems, linear systems with real eigenvalues, linear systems with nonreal eigenvalues, stability and linear classification, linearisation of nonlinear systems, coupled heat and mass transfer problems in steady-state flow systems.

MA1507 Advanced Calculus
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): GCE ‘A’ Level or H2 Mathematics or equivalent
Preclusion(s): MA1102R, MA1104, MA1505, MA1511, MA1512, MA1521, MA2104, MA2311
Cross-listing(s): Nil

The objective of this module is to provide a foundation for calculus of one and several variables. The module is targeted at students in the Engineering Science Programme. Topics: brief review of one variable calculus, sequences and series, tests of convergence and divergence, power series in one variable, interval of convergence, Maclaurin and Taylor series, Taylor’s theorem with remainder, lines and planes, functions of several variables, continuity of functions of several variables, partial derivatives, chain rule, directional derivatives, normal lines and tangent planes to surfaces, extrema of functions, vector-valued functions, curves, tangents and arc length, gradient, divergence and curl, line, surface and volume integrals, Green’s theorem, divergence theorem, Stokes’ theorem.
MA1508 Linear Algebra with Applications *(To be phased out from Semester 1, AY2017/2018)*
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): GCE ‘A’ Level or H2 Mathematics or equivalent
Preclusion(s): MA1101R, MA1311, MA1506
Cross-listing(s): Nil

The objective of this module is to inculcate a facility in both linear algebra and its numerical methods. The module is targeted at students in the Engineering Science Programme. Topics: systems of linear equations, matrices, determinants, numerical solutions of systems of linear equations, vector spaces, subspaces, linear independence, basis and dimension, rank of a matrix, orthogonality and orthonormal bases, linear transformations, eigenvalues and eigenvectors, diagonalisation, numerical methods in approximating eigenvalues.

**MA1508E Linear Algebra for Engineering**
Modular Credits: 4
Workload: 3-2-0-0-5
Prerequisite(s): GCE ‘A’ level or H2 Mathematics or equivalent
Preclusion(s): MA1101R, MA1311, MA1506, MA1508, MA1513 (2 way preclusion)
Cross-listing(s): Nil

The module is targeted at students from the Faculty of Engineering and it provides the basic fundamental principles of Linear Algebra relevant to the field of Engineering. Topics include System of linear equations and their solutions. Gaussian elimination. Matrices, matrix operations and invertibility. Determinant of a matrix. Euclidean space and vectors. Subspaces, linear combinations and linear span. Linear independence, basis and coordinate vectors. Dimension of a vector space. Rank and nullity theorem for matrices. Linear approximation and least squares solution to a linear system. Orthogonal projection. Eigenvalues, eigenvectors and diagonalization. Complex numbers. Applications of eigenvalues and eigenvectors to differential equations.

**MA1511 Engineering Calculus**
Modular Credits: 2
Workload: 3-2-0-0-5
Prerequisite(s): GCE ‘A’ level or H2 Mathematics or equivalent
Preclusion(s): MA1102R, MA1312, MA1505, MA1506, MA1507, MA1521, MA2311, MA2501, EE1461, PC2174 (2 way preclusion)
Cross-listing(s): Nil

This is a seven week-module specially designed for students majoring in Engineering. It introduces the basic concepts in one variable and several variable calculus with applications in engineering. Main topics: One variable calculus. Power series. Partial differentiation. Multiple integrals. Vector Calculus.

**MA1512 Differential Equations for Engineering**
Modular Credits: 2
Workload: 3-2-0-0-5
Prerequisite(s): GCE ‘A’ level or H2 Mathematics or equivalent
Preclusion(s): MA1506, MA1507, EE1461, PC2174 (2 way preclusion)
Cross-listing(s): Nil
This is a seven week-module specially designed for students majoring in Engineering. It introduces the basic concepts in differential equations with applications in engineering. Major topics: First order ordinary differential equations and applications. Second order ordinary differential equations and applications. Partial differential equations and applications. Laplace transforms and applications.

**MA1513 Linear Algebra with Differential Equations**  
Modular Credits: 2  
Workload: 3-2-0-0-5  
Prerequisite(s): GCE ‘A’ level or H2 Mathematics or equivalent  
Preclusion(s): MA1101R, MA1311, MA1506, MA1508, MA1508E (2 way preclusion)  
Cross-listing(s): Nil

This is a six week-module specially designed for students majoring in Engineering. It introduces the basic concepts in linear algebra with applications in engineering. Major topics: Matrix algebra, linear system of equations, vector spaces, linear independence, basis, orthogonality, rank, linear transformations, eigenvalues and eigenvectors, diagonalization, linear systems of differential equations, linearization of nonlinear systems.

**MA1521 Calculus for Computing**  
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): GCE ‘A’ level Mathematics or H2 Mathematics or MA1301 or MA1301FC or MA1301X  
Preclusion(s): MA1102R, MA1312, MA1505, MA1507, MA2501, FoE students  
Cross-listing(s): Nil

This module provides a basic foundation for calculus and its related subjects required by computing students. The objective is to train the students to be able to handle calculus techniques arising in their courses of specialization. In addition to the standard calculus material, the course also covers simple mathematical modeling techniques and numerical methods in connection with ordinary differential equations. Major topics: Preliminaries on sets and number systems. Calculus of functions of one variable and applications. Sequences, series and power series. Functions of several variables. Extrema. First and second order differential equations. Basic numerical methods for ordinary differential equations.

**DSA2102 Essential Data Analytics Tools: Numerical Computation**  
Modular Credits: 4  
Workload: 3-1-0-2-4  
Prerequisite(s): MA1101R and MA1102R  
Preclusion(s): MA2213  
Cross-listing(s): Nil

This module aims at introducing basic concepts and well-established numerical methods that are very related to the computing foundation of data science and analytics. The emphasis is on the tight integration of numerical algorithms, implementation in industrial programming language, and examination on practical examples drawn from various disciplines related to data science. Major topics include: computer arithmetic, matrix multiplication, numerical methods for solving linear systems, least squares method, interpolation, concrete implementations in industrial program language, and sample applications related to data science.
**MA2101 Linear Algebra II**

Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1101R or MA1506 or MA1508 or MA1508E or MA1513
Preclusion(s): MA2101S, MA2101H, MA2201, MA2203, MQ2201, MQ2101, MQ2203
Cross-listing(s): Nil

This module is a continuation of MA1101 Linear Algebra I intended for second year students. The student will learn more advanced topics and concepts in linear algebra. A key difference from MA1101 is that there is a greater emphasis on conceptual understanding and proof techniques than on computations.


**MA2101S Linear Algebra II (S)**

Modular Credits: 5
Workload: 3-2-0-0-8
Prerequisite(s): (MA1101R or MA1506 or MA1508 or MA1508E or MA1513) and departmental approval
Preclusion(s): MA2101, MA2101H, MA2201, MA2203, MQ2201, MQ2101, MQ2203
Cross-listing(s): Nil

The objective of this module is to develop the learning capabilities and hone the problem solving skills of talented students at a mathematically deeper and more rigorous level. In addition to the classes of the regular module, one extra special hour each week will be devoted to solving challenging problems and studying some additional topics and those topics briefly mentioned in the regular module. The contents of this module will consist of those in the regular module (MA2101) and the following additional topics: proofs of Jordan Normal Form Theorem, Cayley Hamilton Theorem, introductory module theory, further applications of linear algebra.

**MA2104 Multivariable Calculus**

Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1102R or MA1505 or MA1511 or MA1521
Preclusion(s): MA1104, MA2311, MA1507, MPE students
Cross-listing(s): Nil

This is a module on the calculus of functions of several real variables, applications of which abound in mathematics, the physical sciences and engineering. The aim is for students to acquire computational skills, ability for 2- and 3-D visualisation and to understand conceptually fundamental results such as Green’s Theorem, Stokes’ Theorem and the Divergence Theorem. Major topics: Euclidean distance and elementary topological concepts in R^n, limit and continuity, implicit functions. Partial differentiation, differentiable functions, differentials, chain rules, directional derivatives, gradients, mean value theorem, Taylor’s formula, extreme value theorem, Lagrange multipliers. Multiple integrals and iterated integrals, change of order of...
integration, applications, Jacobian matrix, change of variables in multiple integrals. Line integrals and Green's theorem. Surface integrals, Stokes' Theorem, Divergence Theorem.

**MA2108 Mathematical Analysis I**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA1102R or MA1505 or MA1505C or MA1507 or MA1511 or MA1521  
Preclusion(s): MA2108S, MA2206, MA2208, MA2221, MA2311, MQ2202, MQ2102, MQ2203, CN2401, EE2401, ME2492  
Cross-listing(s): Nil

The objective of this module is to introduce the student to the contents and methods of elementary mathematical analysis. The course develops rigorously the following concepts arising from calculus: the real number system, sequences and series of constant terms, limit and continuity of functions. The emphasis is on logical rigour. The student will be exposed to and be expected to acquire the skills to read and write mathematical proofs. Major topics: Basic properties of real numbers, supremum and infimum, completeness axiom. Sequences, limits, monotone convergence theorem, Bolzano-Weierstrass theorem, Cauchy's criterion for convergence. Infinite series, Cauchy's criteria, absolute and conditional convergence, tests for convergence. Limits of functions, fundamental limit theorems, one-sided limits, limits at infinity, monotone functions. Continuity of functions, intermediate-value theorem, extreme-value theorem, inverse functions. (Formerly MA2208 Advanced Calculus II)

**MA2108S Mathematical Analysis I (S)**
Modular Credits: 5  
Workload: 3-2-0-0-8  
Prerequisite(s): (MA1102R or MA1505 or MA1505C or MA1507 or MA1511 or MA1521) and departmental approval  
Preclusion(s): MA2108, MA2206, MA2208, MA2221, MA2311, MQ2202, MQ2102, MQ2203, CN2401, EE2401, ME2492  
Cross-listing(s): Nil

The objective of this module is to develop the learning capabilities and hone the problem solving skills of talented students at a mathematically deeper and more rigorous level. In addition to the classes of the regular module, one extra special hour each week will be devoted to solving challenging problems and studying some additional topics and those topics briefly mentioned in the regular module. The contents of this module will consist of those in the regular module (MA2108) and the following additional topics: conditions equivalent to the completeness axiom, rearrangement of series, trigonometric series.

**MA2202 Algebra I**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA1100 or MA1100S or CS1231 or CS1231S  
Preclusion(s): MA2202S, MA3250, MQ3201, CVE students  
Cross-listing(s): Nil
This course introduces basic concepts in group theory. Major topics: Modular arithmetics, Binary operations, Groups. Subgroups, Group homomorphisms, Examples of Symmetric groups and Cayley’s theorem, Cyclic groups, Cosets and Theorem of Lagrange, Fermat’s Little Theorem and Euler’s phi function, Direct products of groups, Normal subgroups, Quotient groups, Isomorphism Theorems, Group actions, Stabilizers and orbits, Examples and applications.

MA2202S Algebra I (S)
Modular Credits: 5
Workload: 3-2-0-0-8
Prerequisite(s): (MA1100 or MA1100S or CS1231 or CS1231S) and departmental approval
Preclusion(s): MA2202, MA3250, MQ3201, CVE students
Cross-listing(s): Nil

The objective of this module is to develop the learning capabilities and hone the problem solving skills of talented students at a mathematically deeper and more rigorous level. The contents of this module will consist of those in the regular module (MA2202 Algebra I) and the following additional topics: Group action, group representations, profinite groups and classical groups

MA2213 Numerical Analysis I
Modular Credits: 4
Workload: 3-1-0-3-3
Prerequisite(s): (MA1102R or MA1312 or MA1507 or MA1505 or MA1511 or MA1521 or EG1402 or EE1401 or EE1461) and (MA1101R or MA1311 or MA1508 or MA1506 or MA1508E or MA1513)
Preclusion(s): CE2407, ME3291, CN3421, CN3411, CHE students (for breadth requirements), EVE students (for breadth requirements), DSA2102
Cross-listing(s): Nil

This is a first course on the theory and applications of numerical approximation techniques. Through the study of this module, the students will gain an understanding of how in practice mathematically formulated problems are solved using computers, and how computational errors are analysed and tackled. The students will be equipped with a number of commonly used numerical algorithms and knowledge and skill in performing numerical computation using MATLAB. The module is intended for mathematics majors and students from engineering and physical sciences. It will provide a firm basis for future study of numerical analysis and scientific computing. Major topics: Computational errors, direct method for systems of linear equations, interpolation and approximation, numerical integration, use of MATLAB software.

MA2214 Combinatorics and Graphs I
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1100 or MA1101R or MA1311 or MA1506 or MA1508 or MA1508E or MA1513 or CS1231 or CS1231S
Preclusion(s): Nil
Cross-listing(s): Nil

The main objective of this module is to introduce to students fundamental principles and techniques in combinatorics as well as the basics of graph theory, which have practical applications in such areas as
computer science and operations research. The major topics from combinatorics are: Permutations and Combinations, Binomial and Multinomial Coefficients, The Principle of Inclusion and Exclusion, Generating Functions, Recurrence Relations, Special Numbers including Fibonacci Numbers, Stirling Numbers, Catalan Numbers, Harmonic Numbers and Bernoulli Numbers. The major topics from graph theory are: Basic Concepts and Results, Bipartite graphs and trees.

**MA2216 Probability**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA1102R or MA1312 or MA1507 or MA1505 or MA1505C or MA1511 or MA1521  
Preclusion(s): ST2131, ST2334, CE2407  
Cross-listing(s): ST2131

The objective of this course is to give an elementary introduction to probability theory for science (including computing science, social sciences and management sciences) and engineering students with knowledge of elementary calculus. It will cover not only the mathematics of probability theory but will work through many diversified examples to illustrate the wide scope of applicability of probability. Topics covered are: combinatorial analysis, axioms of probability, conditional probability and independence, random variables, distributions and joint distributions, expectations, central limit theorem.

**MA2219 Introduction to Geometry**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA1100 or MA1101R or MA1506 or MA1508 or MA1508E or MA1102R or MA1505 or MA1507 or MA1511 or MA1513 or CS1231  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module gives a first introduction to various kinds of geometries ranging from elementary Euclidean geometry on the plane, inversive geometry on the sphere, as well as projective geometry and Non-Euclidean geometry. Topics covered include: Conics, Quadric surfaces, Affine geometry, Affine transformations, Ceva’s theorem, Menelaus’ theorem, Projective geometry, projective transformations, homogeneous coordinates, cross-ratio, Pappus’ theorem, Desargues’ theorem, duality and projective conics, Pascal’s theorem, Brianchon’s theorem, Inversions, coaxal family of circles, Non-Euclidean geometry, Mobius transformations, distance and area in Non-Euclidean geometry.

**MA2288 Basic UROPS in Mathematics I**

Modular Credits: 4  
Workload: 0-0-0-10-0  
Prerequisite(s): MA1101R and departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is entirely project based. It allows the student the opportunity to engage in independent learning and research. It also affords the student the chance to delve into topics that may not be present in the regular curriculum.
**MA2289 Basic UROPS in Mathematics II**

Modular Credits: 4  
Workload: 0-0-0-10-0  
Prerequisite(s): MA1101R and departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This provides a continuation of work done in MA2288 and the project should be of two semesters’ duration.

**MA2311 Techniques in Advanced Calculus**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA1102R or MA1312 or MA1421 or MA1521  
Preclusion(s): MA1104, MA1505, MA1507, MA1511, MA2104, MA2108, MA2108S, MPE students,  
Mathematics majors, Applied Mathematics majors, Quantitative Finance majors, second major in Mathematics, second major in Financial Mathematics  
Cross-listing(s): Nil

(Formerly MA2221 Techniques in Advanced Calculus.)

**MA2312 Introduction to Differential Equations**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): (MA1101R or MA1311) and (MA1102R or MA1312 or MA1421 or MA1505 or MA1521)  
Preclusion(s): MA3220, MA1506, MA2501, Mathematics majors, Applied Mathematics majors, Quantitative Finance majors, second major in Mathematics, second major in Financial Mathematics  
Cross-listing(s): Nil

This module introduces the basic concepts and techniques of differential equations. The objective is to develop a competent working knowledge of the main concepts and methods introduced. It is designed for students who read a minor in mathematics or for those who are keen to pick up some mathematical skills that might be useful in their own areas of studies. Major topics: First-order differential equations. Linear differential equations of second order or higher. System of linear differential equations. Power series solutions and Laplace transforms.
MA2501 Differential Equations and Systems
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1507 and MA1508
Preclusion(s): MA1505, MA1505C, MA1506, MA1521, MA2210, MA2312
Cross-listing(s): Nil

This module has subjects in differential equations and how they can be applied in a variety of different systems. The topics include: first-order differential equations, separation of variables, linearity and nonlinearity, growth and decay phenomena, second-order differential equations, real and complex characteristic roots, forced oscillations, conservative and non-conservative systems, linear systems with real and complex eigenvalues, decoupling linear systems, stability and linear classifications, forced equations and systems, Fourier transforms and applications, nonhomogenous equations, Laplace transforms, stability, feedback and control. Topics covered: First-order differential equations: dynamical system models, solutions and directional fields, separation of variables, solving first-order DE. Linearity and nonlinearity: growth and decay phenomena, linear models: examples, non-linear models: examples. Second-order differential equations: real and complex characteristic roots, forced oscillations, conservative and non-conservative systems. Linear system of differential equations: linear systems with real and complex eigenvalues, decoupling linear systems, stability and linear classifications. Forced equations and systems: Fourier transforms and applications, linear nonhomogenous equations, Laplace transforms, stability, feedback and control.

DSA3102 Essential Data Analytics Tools: Convex Optimisation (from AY2018/2019)
Modular Credits:
Workload: 3-1-0-3-3
Prerequisite(s): CS1010/CS1020E/CS1010S/CS1010X and MA1101R and (MA1104 or MA2104 or MA2311)
Preclusion(s): Nil
Cross-listing(s): Nil

Convex optimisation is an indispensable technique in dealing with high-dimensional structured problems in data science. The module covers modelling examples; basic concepts for convex functions and sub-gradients; gradient and sub-gradient methods; accelerated proximal gradient methods; stochastic block coordinate descent methods; Lagrangian duals; splitting algorithms and implementations.

MA3110 Mathematical Analysis II
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA2108 or MA2108S
Preclusion(s): MA2118, MA2118H, MA2205, MQ3202, MA3110S, ST2236
Cross-listing(s): Nil

This is a continuation of MA2108 Mathematical Analysis I. The objective of this module is to introduce the student to the contents and methods of elementary mathematical analysis. The course develops rigorously the following concepts arising from calculus: the derivative, the Riemann integral, sequences and series of functions. The emphasis is on logical rigour. The student will be exposed to and be expected to acquire the skills to read and write mathematical proofs. Major topics: Differentiation: the derivative, Mean Value Theorem and applications, L'Hospital rules, Taylor's Theorem. The Riemann integral: Riemann integrable functions, the Fundamental Theorem of Calculus, change of variable, integration by parts. Sequences of
functions: Pointwise and uniform convergence, interchange of limits and continuity, derivative and integral, the exponential and logarithmic functions, the trigonometric functions. Series of functions: Cauchy criterion, Weierstrass M-test, power series, radius of convergence, term-by-term differentiation.

**MA3110S Mathematical Analysis II (S)**
Modular Credits: 5  
Workload: 3-2-0-0-8  
Prerequisite(s): (MA2108 or MA2108S) and departmental approval  
Preclusion(s): MA2118, MA2118H, MA2205, MQ3202, MA3110  
Cross-listing(s): Nil  

The objectives of this module are to develop the learning capabilities and hone the problem-solving skills of talented students at a mathematically deeper and more rigorous level. In addition to lectures and tutorials, one extra special hour each week will be devoted to solving challenging problems and studying some additional topics and those topics briefly mentioned in the regular module. The contents of this module will consist of those in the regular module (MA3110) and the following additional topics: differentiation of vector-valued functions, Riemann-Stieltjes integral.

**MA3111 Complex Analysis I**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): (MA1104 or MA1507 or MA2104) and (MA3110 or MA3110S)  
Preclusion(s): MA3111S, EE3002, MPE students  
Cross-listing(s): Nil  

This module is a first course on the analysis of one complex variable. In this module, students will learn the basic theory and techniques of complex analysis as well as some of its applications. Target students are mathematics undergraduate students in the Faculty of Science. Major topics: complex numbers, analytic functions, Cauchy-Riemann equations, harmonic functions, contour integrals, Cauchy-Goursat theorem, Cauchy integral formulas, Taylor series, Laurent series, residues and poles, applications to computation of improper integrals.

**MA3111S Complex Analysis I (S)**
Modular Credits: 5  
Workload: 3-2-0-0-8  
Prerequisite(s): (MA1104 or MA1507 or MA2104) and (MA3110 or MA3110S) and departmental approval  
Preclusion(s): MA3111, EE3002, MPE students  
Cross-listing(s): Nil  

The objective of this module is to develop the learning capabilities and hone the problem-solving skills of talented students at a mathematically deeper and more rigorous level. The contents of this module will consist of those in the regular module (MA3111 Complex Analysis I) and the following additional topics: Casorati-Weierstrass Theorem, infinite products of analytic functions, normal families of analytic functions.
MA3201 Algebra II
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA2202 or MA2202S) and (MA2101 or MA2101S)
Preclusion(s): Nil
Cross-listing(s): Nil
The objective of this module is to provide the essentials of ring theory and module theory. Major topics: rings, ring isomorphism theorems, prime and maximal ideals, integral domains, field of fractions, factorization, unique factorization domains, principal ideal domains, Euclidean domains, factorization in polynomial domains, modules, module isomorphism theorems, cyclic modules, free modules of finite rank, finitely generated modules, finitely generated modules over a principal ideal domain.

MA3205 Set Theory
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1100 or MA1100S or CS1231 or CS1231S
Preclusion(s): Nil
Cross-listing(s): Nil
This is an introductory mathematical course in set theory. There are two main objectives: One is to present some basic facts about abstract sets, such as, cardinal and ordinal numbers, axiom of choice and transfinite recursion; the other is to explain why set theory is often viewed as foundation of mathematics. This module is designed for students who are interested in mathematical logic, foundation of mathematics and set theory itself. Major topics: Algebra of sets. Functions and relations. Infinite sets. Induction and definition by recursion. Countable and uncountable sets. Linear orderings. Well orderings and ordinals. Axiom of choice.

MA3209 Mathematical Analysis III
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA3110 or MA3110S) and (MA1104 or MA1507 or MA2104)
Preclusion(s): MA3213, MA3251
Cross-listing(s): Nil
This module has two main objectives: to introduce analysis in the setting of metric spaces and to present multivariable differential calculus at a more advanced level. Major topics: Metric spaces and examples, topology of metric spaces, convergence of sequences., completeness, continuity of functions and uniform continuity, compactness, contraction mappings, Banach’s fixed point theorem, differentiable functions from $\mathbb{R}^n$ to $\mathbb{R}^m$, inverse function theorem and implicit function theorem.

MA3215 Three-Dimensional Differential Geometry
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA1104 or MA1104S or MA2221 or MA1507 or MA1505 or MA2311) and (MA1101R or MA1311 or MA1506 or MA1508)
Preclusion(s): Nil
Cross-listing(s): Nil

[Items in DARK RED denote changes from this academic year]
Students of this module will learn how to apply their knowledge in advanced calculus and linear algebra to the study of the geometry of smooth curves and surfaces in the three dimensional Euclidean space. Major topics: theory of smooth space curves, differentiable structures on a smooth surface, local theory of the geometry of smooth surfaces and some selected results on the global theory of the geometry of smooth surfaces. (No longer offered from AY2015/16)

MA3218 Applied Algebra
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA2101 or MA2101S
Preclusion(s): MA2202, MA2202S, EE4103
Cross-listing(s): Nil

Modern algebra is used in a variety of areas such as coding theory and cryptography. The focus of this module is to introduce elementary concepts of abstract algebra and some of their applications. Upon completing this module, the student will have some basic knowledge of modern algebra and an understanding of some applications such as those in coding theory and cryptography. Major Topics: Integers, binary operations, groups, cosets, rings, division domain, polynomial rings, fields, finite fields. Introduction to coding theory, block codes, linear codes, Hamming distances, Hamming codes, Reed-Muller codes, cyclic codes, Reed-Solomon codes. Introduction to cryptography, substitution ciphers, permutation cipher, block ciphers. Other applications.

MA3219 Computability Theory
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1100 or MA1100S or CS1231 or CS1231S
Preclusion(s): Nil
Cross-listing(s): Nil

This is an introductory course on the formal theory of computable functions. In particular, we will describe the notion of computability and answer the question whether every function from N (the set of natural numbers) to N is computable. Major topics: Turing machines. Partial recursive functions. Recursive sets. Recursively enumerable sets. Unsolvable problems.

MA3220 Ordinary Differential Equations
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA1104 or MA1505 or MA1507 or MA1511 or MA1521 or MA2104) and (MA1101R or MA1311 or MA1506 or MA1508 or MA1508E or MA1513) and (MA2108 or MA2108S)
Preclusion(s): MA2312, PC2174
Cross-listing(s): Nil

The study of ordinary differential equations (ODEs) has been a centerpiece in both pure and applied mathematics, such as in mathematical analysis, dynamical systems and mathematical modeling. The aim of this module is to give a thorough treatment on the fundamental theory of ODEs and the methods of solving ODEs. Major topics: Review of first order equations, Basic theory of linear differential equations, Variation of

**MA3227 Numerical Analysis II**

Module Credits: 4  
Workload: 3-1-0-3-3  
Prerequisite(s): MA2213 and (MA1104 or MA1506 or MA1507 or MA1505 or **MA1511 or MA2104 or MA2311**) and (MA2101 or MA2101S) and (MA2216 or ST2131 or ST2334)  
Preclusion(s): ME3291  
Cross-listing(s): Nil

This module is a continuation of MA2213 Numerical Analysis I. It introduces and analyzes important numerical methods for solving linear and nonlinear systems, two-point boundary value problems, as well as Monte Carlo methods and their applications in such fields as quantitative finance and physics. The module aims at developing students’ problem-solving skills in emerging applications of modern scientific computing, and is intended for mathematics and quantitative finance majors and students from engineering, computer science and physical sciences. Major topics: Iterative methods for systems of linear equations and their convergence analysis, numerical solutions of systems of nonlinear equations, methods for solving two-point boundary value problems, Monte Carlo methods and their applications.

**MA3229 Introduction to Geometric Modelling**

Module Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): (MA1104 or MA1505 or MA1507 or **MA1511 or MA2104 or MA2311**) and (MA1101R or MA1506 or MA1508 or MA1508E or MA1513)  
Preclusion(s): Nil  
Cross-listing(s): Nil

Geometric modelling combines elementary geometry, analysis and computing for applications in various disciplines in science and technology, such as computer aided design, computer graphics, biomedical modeling and visualization. The course involves modeling, design and analysis of freeform curves and surfaces and covers the basic mathematics and algorithms. Topics covered include Bernstein polynomials, de Casteljau algorithm, Bezier curves, curve splitting, composite Bezier curves, geometric continuity, tensor product Bezier surfaces; Chaikin's algorithm, uniform Bsplines, refinement equations, uniform B-spline curves and surfaces, uniform B-spline subdivision algorithms; Non-uniform B-splines, recurrence relations, derivatives, discrete B-splines, nonuniformmm B-spline curves and surfaces, discrete B-spline algorithm, homogeneous coordinates and projective transformations, non-uniform rational B-splines (NURBS), NURBS curves and surfaces. NURBS is the current industry standard in computer aided design and computer graphics.
MA3233 Combinatorics and Graphs II
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA2214
Preclusion(s): Nil
Cross-listing(s): Nil

This is a continuation of MA2214 Combinatorics and Graphs I. The objective is to introduce to students fundamental principles and techniques in Graph Theory. Major topics: Connectivity, Eulerian Multigraphs and Hamiltonian Graphs, Matching, Covering and Independence, Vertex Coloring (including basics of Planar Graphs), Digraphs, Basic Spectral Graph Theory (including Eigenvalues of Graphs and Graph Laplacians).

MA3236 Non-Linear Programming
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1104 or MA1506 or MA1507 or MA1505 or MA1511 or MA2104 or MA2311
Preclusion(s): DSC3214 or DSN3701
Cross-listing(s): Nil

Optimisation principles are of undisputed importance in modern design and system operation. The objective of this course is to present these principles and illustrate how algorithms can be designed from the mathematical theories for solving optimisation problems. Major topics: Fundamentals, unconstrained optimisation: one-dimensional search, Newton-Raphson method, gradient method, constrained optimisation: Lagrangian multipliers method, Karush-Kuhn-Tucker optimality conditions, Lagrangian duality and saddle point optimality conditions, convex programming: Frank-Wolfe method.

MA3238 Stochastic Processes I
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA1101 or MA1101R or MA1311 or MA1508 or GM1302) and (MA2216 or ST2131)
Preclusion(s): ST3236, ISE students
Cross-listing(s): ST3236

This module introduces the concept of modelling dependence and focuses on discrete-time Markov chains. Major topics: discrete-time Markov chains, examples of discrete-time Markov chains, classification of states, irreducibility, periodicity, first passage times, recurrence and transience, convergence theorems and stationary distributions.
MA3245 Financial Mathematics I
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA1104 or MA1104S or MA1506 or MA1507 or GM1307) and (MA2222 or QF2101)
Preclusion(s): Nil
Cross-listing(s): Nil

This module introduces students to basic option theory and the pricing formula for the Black-Scholes model. Topics include binomial trees, replicating portfolios, arbitrage, hedging, risk neutrality, riskless trading strategies, partial differential equations, stochastic differential equations, Ito’s Lemma, Black-Scholes formula and numerical procedures. This module targets all students who have an interest in computational finance.

MA3252 Linear and Network Optimisation
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1101 or MA1101R or MA1306 or MA1311 or MA1508 or MA1506 or MA1508E or MA1513 or GM1306
Preclusion(s): GM2302, MQ2204, CS3252, IC2231, DSC3214, DSN3701, GM3308, MA3235, BH3214, ISE students
Cross-listing(s): Nil

The objective of this course is to work on optimisation problems which can be formulated as linear and network optimisation problems. We formulate linear programming (LP) problems and solve them by the simplex method (algorithm). We also look at the geometrical aspect and develop the mathematical theory of the simplex method. We further study problems which may be formulated using graphs and networks. These optimisation problems can be solved by using linear or integer programming approaches. However, due to its graphical structure, it is easier to handle these problems by using network algorithmic approaches. Applications of LP and network optimisation will be demonstrated. This course should help the student in developing confidence in solving many similar problems in daily life that require much computing.


MA3256 Applied Cryptography
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA2202
Preclusion(s): CS4233
Cross-listing(s): Nil

Authentication. Digital signature and cryptographic applications (e.g. smart card).

**MA3259 Mathematical Methods in Genomics**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA2216 or MA3233 or MA3501 or ST2131 or ST2334 or LSM2241  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is an introduction to methods and popular software tools for solving computational problems in genomics. It studies exact algorithms for those problems that can be solved easily and approximation and/or heuristic algorithms for hard problems. The objective is to develop competitive knowledge in formulating biological problems in computational terms and solving these problems using algorithm approach. This module is for students with interests in computational molecular biology and bioinformatics. Major topics: Sequence analysis, multiple sequence alignment, phylogenetic analysis, genome sequencing, gene prediction and motif finding, genome rearrangement.

**MA3264 Mathematical Modelling**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA1104 or MA1104S or MA1506 or MA1511 or MA2104 or MA2108 or MA2108S or MA2221 or MA1505 or MA2311  
Preclusion(s): MPE students  
Cross-listing(s): Nil

The objective of this course is to introduce the use of mathematics as an effective tool in solving real-world problems through mathematical modelling and analytical and/or numerical computations. By using examples in physical, engineering, biological and social sciences, we show how to convert real-world problems into mathematical equations through proper assumptions and physical laws. Qualitative analysis and analytical solutions for some models will be provided to interpret and explain qualitative and quantitative phenomena of the real-world problems. Major topics: Introduction of modelling; dynamic (or ODE) models: population models, pendulum motion; electrical networks, chemical reaction, etc; optimisation and discrete models: profit of company, annuity, etc; probability models: president election poll, random walk, etc; Model Analysis: dimensional analysis, equilibrium and stability, bifurcation, etc; and some typical applications.

**MA3265 Introduction to Number Theory**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): (MA2108 or MA2108S) and (MA2202 or MA2202S)  
Preclusion(s): Nil  
Cross-listing(s): Nil

Number theory is an area that attracts the attention of many great mathematicians. Attempts to solve some number theoretic problems (such as the Fermat’s Last Theorem) often lead to new areas of mathematics. A recent application of an elementary number theoretic result called the Euler’s Theorem to cryptography (RSA system) has further established the importance of this area in applied mathematics. The aim of this
The course is to introduce various topics in number theory and to connect these topics with algebra, analysis, and combinatorics.

Major topics: Prime numbers, multiplicative functions, theory of congruences, quadratic residues, algebraic numbers and integers, sums of squares and gauss sums, continued fractions, transcendental numbers, quadratic forms, genera and class group, partitions, diophantine equations, basic theory of elliptic curves.

**MA3266 Introduction to Fourier Analysis**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): (MA1101R or MA1506 or MA1508 or MA1508E or MA1513) and MA1104 or MA2104 and MA3220  
Preclusion(s): Nil  
Cross-listing(s): Nil  

The aim of this module is to introduce the ideas of Fourier analysis, which permeate much of the present-day mathematics, and to develop some of its applications in analysis and partial differential equations. The emphasis of the module is on methods and applications. Major topics: Fourier Series and Basic Properties. Convergence of Fourier Series. Partial Differential Equations of Physics. Boundary Value Problems and the Fourier Method; Fourier Integrals and Applications. Orthogonal Systems. Sturm-Liouville Problems.

**MA3269 Mathematical Finance I**

Modular Credits: 4  
Workload: 3-1-0-2-4  
Prerequisite(s): (CS1010 or CS1010E or CS1010S or CS1010FC or IT1006 or CS1101 or CS1101C or CS1101S or IT1002) and (ST2131 or ST2334 or MA2216)  
Preclusion(s): QF2101  
Cross-listing(s): Nil  

This module introduces the students to the basics of financial mathematics and targets all students who have an interest in building a foundation in financial mathematics. Topics include basic mathematical theory of interest, term structure of interest rates, fixed income securities, risk aversion, basic utility theory, single-period portfolio optimization, basic option theory. Mathematical rigor will be emphasized.

**MA3288 Advanced UROPS in Mathematics I**

Modular Credits: 4  
Workload: 0-0-0-10-0  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil  

This module is entirely project based. It allows the student the opportunity to engage in independent learning and research. It also affords the student the chance to delve into topics that may not be present in the regular curriculum. Projects registered under MA3288 are intended to be at a more advanced level than those under MA2288/9.
MA3289 Advanced UROPS in Mathematics II
Modular Credits: 4
Workload: 0-0-0-10-0
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module provides a continuation of work done in MA3288 and the project should be of two semesters’ duration.

MA3291 Undergraduate Seminar in Mathematics
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): (MA2101 or MA2101S) and (MA2108 or MA2108S)
Preclusion(s): Nil
Cross-listing(s): Nil

The seminar module aims to train the students’ ability to present, discuss and write about mathematics. The topic(s) for the module will be chosen by the instructor and may change from year to year. Students will give presentations and contribute to the discussion at seminars. They may collaborate in studying the topics, but each will write an individual report. Students may also be tested on their grasp of the mathematical content through other forms of assessment.

MA3501 Mathematical Methods in Engineering
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA1506 or MA2501 or EG1402 or EE1401 or EE1461
Preclusion(s): PC2134, CE2407
Cross-listing(s): Nil

The objective of this module is to provide the fundamental concepts and mathematical methods needed for the analytical solution of many ordinary and partial differential equations which arise in the modelling of basic phenomena in science, engineering and technology. The aim of the course is to show how these methods are effectively applied, with the aid of suitable mathematical software. This module provides (i) the basic probabilistic concepts and statistical methods needed for hypothesis testing, (ii) the elements of the theory of functions of one complex variable and (iii) the analytical methods of solving systems of ordinary differential equations and of partial differential equations. The emphasis will be on applications in engineering and technology. A mathematical software such as MATLAB or Maple will be used throughout the course to demonstrate the use of software in problem solving.
MA4199 Honours Project in Mathematics
Modular Credits: 12
Workload: 0-0-0-30-0
Prerequisite(s): Only for students matriculated from 2002/03, subject to faculty and departmental requirements
Preclusion(s): Nil
Cross-listing(s): Nil

The Honours project is intended to give students the opportunity to work independently, to encourage students develop and exhibit aspects of their ability not revealed or tested by the usual written examination, and to foster skills that could be of continued usefulness in their subsequent careers. The project work duration is one year (including assessment).

MA4201 Commutative Algebra
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA3202 or MA3203 or MA3201
Preclusion(s): Nil
Cross-listing(s): Nil

This is a second course on commutative rings and is targeted at aspiring undergraduates who intend to pursue a graduate course in pure mathematics and wish to have some commutative algebra background. Commutative algebra has applications in many areas of abstract algebra, including representation theory, number theory and algebraic geometry. Major topics: Radicals of commutative rings, Nakayama’s lemma, localisation, integral dependence, primary decomposition, Noetherian and Artinian rings.

MA4203 Galois Theory
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA3201
Preclusion(s): Nil
Cross-listing(s): Nil

The objective of this course is to study field theory and its application to classical problems such as squaring a circle, trisecting an angle and solving the quintic polynomial equation by radicals. Major topics: Field extensions, finite and algebraic extensions, automorphisms of fields, splitting fields and normal extensions, separable extensions, primitive elements, finite fields, Galois extensions, roots of unity, norm and trace, cyclic extensions, solvable and radical extensions.
(Formerly MA4203 Field Theory)

MA4204 Group Theory
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA2202 or MA2202S
Preclusion(s): Nil
Cross-listing(s): Nil

[Items in DARK RED denote changes from this academic year]
This course is targeted at advanced mathematics undergraduates who are interested in abstract algebra. It is a second course in group theory in which the group structure is explored using several techniques. Major topics: Isomorphism theorems, group actions, Sylow’s theorems, classification theorem of finitely generated abelian groups and the Jordan-Holder theorem. Series of groups: soluble, Nilpotent groups. Examples of non-abelian simple groups from symmetric groups and general linear groups.

**MA4207 Mathematical Logic**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3110 or MA3110S or MA3205 or MA3219  
Preclusion(s): Nil  
Cross-listing(s): Nil

This is an introductory mathematical course in logic. It gives a mathematical treatment of basic ideas and results of logic, such as the definition of truth, the definition of proof and Godel’s completeness theorem. The objectives are to present the important concepts and theorems of logic and to explain their significance and their relationship to other mathematical work. Major topics: Sentential logic. Structures and assignments. Elementary equivalence. Homomorphisms of structures. Definability. Substitutions. Logical axioms. Deducibility. Deduction and generalisation theorems. Soundness, completeness and compactness theorems. Prenex formulas.

**MA4211 Functional Analysis**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3207H or MA3209  
Preclusion(s): Nil  
Cross-listing(s): Nil

This course is for students who are majors in pure mathematics or who need functional analysis in their applied mathematics courses. The objective of the module is to study linear mappings defined on Banach spaces and Hilbert spaces, especially linear functionals (real-valued mappings) on L(p), C[0,1] and some sequence spaces. In particular, the four big theorems in functional analysis, namely, Hahn-Banach theorem, uniform boundedness theorem, open mapping theorem and Banach-Steinhaus theorem will be covered. Major topics: Normed linear spaces and Banach spaces. Bounded linear operators and continuous linear functionals. Dual spaces. Reflexivity. Hahn-Banach Theorem. Open Mapping Theorem. Uniform Boundedness Principle. Banach-Steinhaus Theorem. The classical Banach spaces : c0, lp, Lp, C(K). Compact operators. Inner product spaces and Hilbert spaces. Orthonormal bases. Orthogonal complements and direct sums. Riesz Representation Theorem. Adjoint operators.

**MA4221 Partial Differential Equations**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3220  
Preclusion(s): Nil  
Cross-listing(s): Nil
The objective of this introductory course is to provide the basic properties of partial differential equations as well as the techniques to solve some partial differential equations. Partial differential equations are the important tools for understanding the physical world and mathematics itself. This course will cover three types of partial differential equations and will provide a broad perspective on the subject, illustrate the rich variety of phenomena and impart a working knowledge of the most important techniques of analysis of the equations and their solutions. Major topics: First-order equations. Quasi-linear equations. General first-order equation for a function of two variables. Cauchy problem. Wave equation. Wave equation in two independent variables. Cauchy problem for hyperbolic equations in two independent variables. Heat equation. The weak maximum principle for parabolic equations. Cauchy problem for heat equation. Regularity of solutions to heat equation. Laplace equation. Green’s formulas. Harmonic functions. Maximum principle for Laplace equation. Dirichlet problem. Green’s function and Poisson’s formula.
(Formerly MA4221 Partial Differential Equations I)

**MA4229 Approximation Theory**
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA2101 or MA2101S) and (MA3110 or MA3110S)
Preclusion(s): Nil
Cross-listing(s): Nil

The central theme of this course is the problem of interpolating data by smooth and simple functions. To achieve this goal, we need to study interesting families of functions. The basic material covered deals with approximation in normed linear spaces, in particular, in Hilbert spaces. These include Weierstrass approximation theorem via Bernstein polynomials, best uniform polynomial approximation, interpolation, orthogonal polynomials and least squares problems, splines and wavelets. Major topics: Basics in approximation theory. Weierstrass approximation theorem via Bernstein polynomials. Best uniform polynomial approximation and Haar condition. Polynomial interpolation. Orthogonal polynomials and least squares problems. Splines. Wavelets.

**MA4230 Matrix Computation**
Modular Credits: 4
Workload: 3-1-0-3-3
Prerequisite(s): (MA2101 or MA2101S) and (DSA2102 or MA2213)
Preclusion(s): Nil
Cross-listing(s): Nil

This course provides essential ideas and techniques as well as algorithms in numerical linear algebra that are needed in scientific computing and data analytics for effectively working with vectors and matrices. The major difficulties faced in solving problems in linear algebra numerically are discussed, as well as the associated applications often seen in practice. The emphasis is on the development of elegant and powerful algorithms and their applications for solving practical problems. Major topics include basic vector and matrix manipulation, the singular value decomposition, QR factorization, least squares problems, conditioning and stability, eigenvalue problems, and various applications in scientific computing and data science.
**MA4233 Dynamical Systems**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3220  
Preclusion(s): Nil  
Cross-listing(s): Nil

The theory of dynamical systems studies the long-term behavior of evolving systems. The aim of the module is to introduce fundamental elements of the mathematical theory of dynamical systems, understand nonlinear phenomena including chaos and bifurcation, and illustrate some of the most important ideas and methods to analyze nonlinear systems. Major topics: dynamics of circle maps, structural stability; dynamics of interval maps, symbolic dynamics and chaos, kneading sequence; bifurcation theory for one-dimensional maps; examples of higher dimensional dynamics.

**MA4235 Topics in Graph Theory**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3233  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module covers some advanced as well as special topics in Graph Theory. The topics are to be chosen from: Domination Theory, Edge Coloring, List Coloring, Graph Ramsey Theory, Chromatic Polynomials, Reconstruction Problem, Planar Graphs, Perfect Graphs, Matroid Theory.

**MA4247 Complex Analysis II**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3111 or MA3111S  
Preclusion(s): Nil  
Cross-listing(s): Nil

This is a second course in complex analysis which aims to introduce the student to some of the beautiful main results and applications of complex analysis. The nature of the topic allows the student to learn and understand the proofs and applications of some very strong results with relatively little background, it also shows the interplay between geometry, analysis and algebra. Major topics: Argument principle (including Rouche’s Theorem), open mapping theorem, maximum modulus principle, conformal mapping and linear fractional transformations, harmonic functions, and analytic continuation.  
(Formerly MA3212 Complex Analysis II)

**MA4248 Theoretical Mechanics**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA2108 or MA2108S or MA2212 or PC2212  
Preclusion(s): MA3224  
Cross-listing(s): Nil
This course develops the Newtonian, Lagrangian and Hamiltonian formulation of mechanics starting from basic concepts of affine geometry and Newton’s three laws as recast in a logical way, where the concepts of mass and force are shown to be derived from the symmetry properties characteristic of empirical measurements. Major topics: Motion in a central force field and Kepler’s three laws of planetary motion, D’Alembert’s principle of virtual work, Lagrange’s equations of motion, Legendre transformations and Hamilton’s equations of motion, geodesics description of inertial motion, Euler’s equation for rigid body motion, Noether’s theorem, canonical transformations, and the Hamilton-Jacobi equations.

(Formerly MA3224 Theoretical Mechanics.)

**MA4251 Stochastic Processes II**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3238 or ST3236  
Preclusion(s): MA3237, MA3239, GM3310, ST4238, ISE students  
Cross-listing(s): ST4238

This module builds on ST3236 and introduces an array of stochastic models with biomedical and other real world applications. Major topics: Poisson process, compound Poisson process, marked Poisson process, point process, epidemic models, continuous time Markov chain, birth and death processes, martingale.

**MA4252 Advanced Ordinary Differential Equations**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3220  
Preclusion(s): Nil  
Cross-listing(s): Nil

The field of ordinary differential equations (ODEs) is a fundamental area in mathematics. There is a great range of real-world phenomena to which the theory and methods of ODEs can be applied. The central aim of this course is to study the qualitative aspects of ODEs. Major topics: Review of firstorder non-linear equations (including continuous dependence on initial conditions). Linear systems, periodic systems, asymptotic behaviour. Stability theory, stable, unstable and asymptotically stable solutions. Lyapunov’s direct method. Two dimensional autonomous systems, critical points, phase portrait, limit cycles and periodic solutions, Poincare-Bendixson Theorem.

**MA4254 Discrete Optimisation**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): DSC3214 or DSN3701 or MA2215 or MA3252  
Preclusion(s): MA3235, ISE students  
Cross-listing(s): Nil

Discrete optimisation deals with problems of maximising or minimising a function over a feasible region of discrete structure. These problems come from many fields like operations research, management science and computer science. The primary objective of this module is twofold: (a) to study key techniques to separate easy problems from difficult ones and (b) to use typical methods to deal with difficult problems. Major topics:
Integer programming: cutting plane techniques, branch and bound enumeration, partitioning algorithms, the fixed charge and plant location problems. Sequencing and job-shop scheduling. Vehicle routing problems.

**MA4255 Numerical Methods in Differential Equations**
Modular Credits: 4  
Workload: 3-1-0-3-3  
Prerequisite(s): *(DSA2102 or MA2213) and MA3220*  
Preclusion(s): ME4233  
Cross-listing(s): Nil

Ordinary and partial differential equations are routinely used to model a variety of natural and social phenomena. This course is concerned with the basic theory of numerical methods for solving these equations. Through the study of this module, students will gain an understanding of (1) various numerical integration schemes for solving ordinary differential equations, and (2) finite difference methods for solving various linear partial differential equations. Major topics: (ODE) One-step and linear multistep methods, Runge-Kutta methods, A-stability, convergence; (PDE) Difference calculus, finite difference methods for initial value problems, boundary value problems, and initial-boundary value problems, consistency, stability analysis via von Neumann method and matrix method, convergence, Lax Equivalence Theorem.  
(Formerly MA4255 Numerical Partial Differential Equations)

**MA4257 Financial Mathematics II**
Modular Credits: 4  
Workload: 3-1-0-3-3  
Prerequisite(s): MA3245  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for honours students in the Computational Finance programme. It aims to impart to students more in-depth knowledge of derivative pricing, hedging and respective risk management considerations in equity, currency and fixed income markets. Major topics: Financial market fundamentals, volatility smile, improvement of Black-Scholes model, American and Bermudan options and their computation, exotic and path-dependent options, fixed income market and term-structure models, interest rate derivatives.

**MA4260 Stochastic Operations Research**
Modular Credits: 4  
Workload: 3-1-0-6  
Prerequisite(s): *(MA2216 or ST2131 or ST2334) and (MA3236 or MA3252 or DSC3214 or DSN3701 or CS3252)*  
Preclusion(s): ISE students  
Cross-listing(s): Nil

This is a stochastic operations research module and has many applications in production planning, warehousing and logistics. This module gives an introduction on how operations research models (with emphasis on optimisation models) are formulated and solved. Many inventory and queuing models are derived to cater for different situations and problems in the real world. The solutions of these models can be obtained analytically. The tools of dynamic programming, heuristics and simulation are also introduced to derive the solutions.

**MA4261 Coding and Cryptography**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3201 or MA3218 or MA3265  
Preclusion(s): EEE students, CEG students, CPE students  
Cross-listing(s): Nil

Error-correcting codes and security codes are very important in the data communication and storage. The focus of this module is the mathematical aspect of coding theory and cryptography. Upon completing this module, the student will have a basic appreciation of some key issues in coding theory and cryptography, some understanding of the basic theory concerning codes and ciphers and a good knowledge of some well-known codes and ciphers. Major Topics: Communication channels and Shannon’s theorem, block codes and linear codes, maximum-likelihood decoding and syndrome decoding, bounds on codes and optimal codes, cyclic codes, BCH codes, encoding and decoding of cyclic codes. Public-key cryptography, RSA cryptosystem, public-key cryptosystems based on the discrete logarithm problem, elliptic curve cryptosystems, factorization algorithm and pseudoprime.

**MA4262 Measure and Integration**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA3209  
Preclusion(s): Nil  
Cross-listing(s): Nil

(Formerly MA3207H Lebesgue Integration)

**MA4263 Introduction to Analytic Number Theory**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): (MA2202 or MA2202S) and (MA3111 or MA3111S)  
Preclusion(s): Nil  
Cross-listing(s): Nil

[Items in DARK RED denote changes from this academic year]
The aim of this course is to introduce the standard techniques in analytic number theory through the study of two classical results, namely, the prime number theorem and Dirichlet’s theorem on primes in arithmetic progressions. Major topics: Arithmetical functions. Merten’s estimates. Riemann zeta function. Prime number theorem. Characters of abelian groups. Dirichlet’s theorem on primes in arithmetic progression.

MA4264 Game Theory
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA3236 or MA3252 or DSC3214 or DSN3701) and (MA2216 or ST2131 or ST2334)
Preclusion(s): EC3312
Cross-listing(s): Nil

Game theory provides a mathematical tool for multi-person decision making. The aim of this module is to provide an introduction to game theory, studying basic concepts, models and solutions of games and their applications. Major topics: Games of normal form and extensive form; Applications in Economics; Relations between game theory and decision making. Games of complete information: Static games with finite or infinite strategy spaces, Nash equilibrium of pure and mixed strategy; Dynamic games, backward induction solutions, information sets, subgame-perfect equilibrium, finitely and infinitely repeated games. Games of incomplete information: Bayesian equilibrium; First price sealed auction, second price sealed auction, and other auctions; Dynamic Bayesian games; Perfect Bayesian equilibrium; Signalling games. Cooperative games: Bargaining theory; Cores of n-person cooperative games; The Shapley value and its applications in voting, cost sharing, etc.
(Formerly MA3247 Decision Making and Game Theory)

MA4266 Topology
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA3209
Preclusion(s): Nil
Cross-listing(s): Nil

The (point-set) topology covered in this module is an abstraction of metric space concepts, and was largely developed in the first half of last century. It forms the basis for much modern mathematics, especially in geometry and analysis, and beyond mathematics is important in computer science, mathematical economics, mathematical physics and robotics. Major topics: metric and topological spaces, continuous maps, bases, homeomorphisms, subspaces, sum, product and quotient topologies, orbit spaces, separation axioms, compact spaces, Tychonoff’s theorem, compactness in metric spaces, Urysohn’s lemma, Tietze Extension Theorem, connected and path-connected spaces, components, locally compact spaces, function spaces and the compact-open topology.
MA4267 Discrete Time Finance
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA3245 (for students enrolled in the Faculty of Science)
Preclusion(s): Nil
Cross-listing(s): Nil

MA4268 Mathematics for Visual Data Processing
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): MA2213
Preclusion(s): Nil
Cross-listing(s): Nil

This multidisciplinary module focuses on various important mathematical methods addressing problems arising in imaging and vision. Topics covered include: Continuous and discrete Fourier transform, Gabor transform, Wiener filter, variational principle, level set method, applied differential geometry, linear and nonlinear least squares, regularisation methods.

MA4269 Mathematical Finance II
Modular Credits: 4
Workload: 3-1-0-3-3
Prerequisite(s): (MA1104 or MA1506 or MA1507 or MA2104 or MA2311) and MA3269
Preclusion(s): MA3245, MA4257
Cross-listing(s): Nil

This module imparts to students in-depth knowledge of pricing and hedging of financial derivatives in equity, currency and fixed income markets. Major topics include fundamental of asset pricing, basic stochastic calculus, Ito’s formula, Black-Scholes models for European, American, path-dependent options such as Barrier, Asian and Lookback options, as well as multi-asset options and American exchange options.

MA4270 Data Modelling and Computation
Modular Credits: 4
Workload: 3-1-0-2-4
Prerequisite(s): (DSA2102 or MA2213) and (MA2216 or ST2131 or ST2334)
Preclusion(s): Nil
Cross-listing(s): Nil

[Items in DARK RED denote changes from this academic year]
This course aims at presenting important mathematical concepts and models as well as computational methods that are often used for modelling and analysis of big data sets and complex networks. The emphasis is on mathematical modelling and computational methods for practical problems in data science. Major topics include: Convex minimization, Dimension reduction, Linear methods for classification, Kernel methods for pattern analysis, Mixture models and clustering, Sparse coding and dictionary learning.

**MA4271 Differential Geometry of Curves and Surfaces**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): (MA1104 or MA1507 or MA1505 or MA2104 or MA2311) and (MA2101 or MA2101S)  
Preclusion(s): MA3215  
Cross-listing(s): Nil

Students of this module will learn how to apply their knowledge in advanced calculus and linear algebra to the study of the geometry of smooth curves and surfaces in the three dimensional Euclidean space. Major topics: theory of smooth space curves, differentiable structures on a smooth surface, local theory of the geometry of smooth surfaces, the first and second fundamental form, Guass map, parallel transport, geodesics, global properties of surfaces: triangulation, Euler number and orientation, global Gauss-Bonnet formula and its applications.

**MA4272 Mathematical Tools for Data Science**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA2213 and (MA3236 or MA3252 or MA3264)  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module introduces the mathematical tools for data science. Its objective is for students to develop competitive knowledge for working in the industry. It is offered to students with interests in industrial applications of mathematics. Major topics include basic mathematics in visualization and analyses of big data, basic principles and computational tools for high-dimensional data from imaging and sensing, basic programming techniques for optimization modelling, and popular software tools for data analytics.

**MA4291 Undergraduate Topics in Mathematics I**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This topics module is intended as an elective module for strong and motivated students specialising in mathematics. The topics for the module will be chosen from a fundamental area of mathematics and may change from year to year. Besides regular lectures, each student will do independent study, give presentations and submit a term paper. There will be opportunities in the course for the students to conduct individual or group research on the topics discussed.
**MA4292 Undergraduate Topics in Mathematics II**

Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This topics module is intended as an elective module for strong and motivated students specialising in mathematics. The topics for the module will be chosen from a fundamental area of mathematics and may change from year to year. Besides regular lectures, each student will do independent study, give presentations and submit a term paper. There will be opportunities in the course for the students to conduct individual or group research on the topics discussed.

**MA5198 Graduate Seminar Module in Mathematics**

Modular Credits: 4  
Workload: 2-0-0-1-7  
Prerequisite(s): Only for graduate research students in the Department of Mathematics who matriculated in 2004 or later  
Preclusion(s): Nil  
Cross-listing(s): Nil

A theme or one or several topics in mathematics, which may vary from semester to semester, will be chosen by the lecturer-in-charge or students enrolled in the module. Students will take turns to give seminar presentations on the chosen topics. Students will also be required to provide verbal critique and submit written reports on selected presentations.

**MA5201 Rings, Modules and Categories (Defunct wef Semester 1, AY2017/2018)**

Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA3203 or MA3202 or MA4201  
Preclusion(s): Nil  
Cross-listing(s): Nil

Target audience consists of graduate and Honours students interested in modern mathematical developments. The main aim of this course is to promote mathematical maturity and the skills needed for independent mathematical scholarship. In terms of content, we do this by introducing category theory as a unifying language for modern mathematics. This will help students to reflect on interactions between different parts of mathematics. In terms of methodology, the module encourages friendly, open discussion of mathematical ideas, teamwork and self-initiated reading of the mathematical literature. Thus class participation and a book review form part of the assessment. Major topics: Rings and ideals, Modules, Exact sequences, Free and projective modules, Noetherian and Artinian rings and modules, Algebras, group rings and polynomial rings, Categories, Functors, natural transformations, Universal constructions and adjoint functors, Tensor products and exactness, Localisation and completion.
**MA5202 Number Theory**
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA4203 or MA5203 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is an introduction to classical algebraic number theory. It covers topics chosen from: algebraic integers, unique factorization of ideals, class group, unit theorem, ramification, decomposition and inertia groups, geometry of numbers, zeta functions and L-functions. If time permits, further topics which may be covered include: p-adic numbers, adeles and ideles, prime number theorem and modular forms.

**MA5203 Graduate Algebra I**
Modular Credits: 5
Workload: 4-0-0-0-8
Prerequisite(s): MA3201 and departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is designed for graduate students in both pure and applied mathematics. It covers topics from the five basic areas of groups, rings, modules, fields and multi-linear algebra, including group actions, Sylow theorems, Jordan-Holder theorem, semisimple modules, chain conditions, bimodules, tensor products and localizations, algebraic, separable and normal field extensions, algebraic closures, multilinear forms, quadratic forms, symmetric and exterior algebras.

**MA5204 Graduate Algebra II A**
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA5203 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is a basic introduction to commutative and homological algebra. It covers the following topics: prime spectrum of a commutative ring, exact sequences, projective, injective and flat modules, Ext and Tor, integral ring extensions, Noether’s normalization and Hilbert’s Nullstellensatz, Noetherian and Artinian rings and moduels, dimension theory, Dedekind domains and discrete valuation ring.

**MA5205 Graduate Analysis I**
Modular Credits: 5
Workload: 4-0-0-0-8
Prerequisite(s): MA4262 or departmental approval
Preclusion(s): MA5215
Cross-listing(s): Nil

This module covers Lebesgue integration and related topics. It is intended for graduate students in mathematics. Major topics include Quick review of properties of $\mathbb{R}^n$, Lebesgue measure on $\mathbb{R}^n$, Borel sets,
Lebesgue nonmeasurable sets, Riemann-Lebesgue function, Lusin’s and Egoroff’s Theorems, convergence in measure. Lebesgue integration, convergence theorems, evaluation of the integral in terms of the distribution function, $L^p$ spaces, density of $C^\infty$ functions in $L^p(\mathbb{R}^n)$, $p < \infty$, abstract integration. Product integration, Fubini’s and Tonelli’s Theorems, application to convolution, approximate identities and maximal function. Lebesgue Differentiation Theorem, Vitali covering, functions of bounded variation, absolutely continuous functions.

**MA5206 Graduate Analysis II**

Modular Credits: 4
Workload: 3-0-0-7
Prerequisite(s): MA4211 and (MA4262 or MA5205), or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module covers basic functional analysis and selected applications. It is intended for graduate students in mathematics.

Major topics:
- Norms and seminorms, Banach and Fréchet spaces, Hahn-Banach and separation theorems, Uniform Boundedness Principle, Open Mapping and Closed Graph Theorems.
- Dual spaces, uniformly convex and reflexive spaces, Radon-Nikodym Theorem and the dual of $L^p$, Banach-Alaoglu’s Theorem, Mazur’s Theorem, adjoint operators.
- Compact operators, compactness of adjoint, spectral theory and Fredholm alternative for compact operators, application to differential equations.

**MA5208 Algebraic Geometry**

Modular Credits: 4
Workload: 3-0-0-7
Prerequisite(s): MA3201 or MA5203 or MA5204 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is a first course in algebraic geometry, introducing the basic objects (varieties) and basic geometric constructs and notions (products, fibers of morphisms, dimensions, tangent spaces, smoothness) with applications to curves and surfaces. It is suitable for students who intend to work in number theory, representation theory, algebraic geometry and topology and geometry in general.
(Formerly MA5208 Algebraic Geometry II)

**MA5209 Algebraic Topology**

Modular Credits: 4
Workload: 3-0-0-7
Prerequisite(s): MA3251 or MA4215 or MA4266 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
This module studies topology using algebraic methods. It covers the following major topics: Fundamental groups, covering spaces, computation of fundamental groups, van Kampen Theorem, the classification of covering spaces, braid groups, simplicial complexes, simplicial homology, simplicial approximation, maps of spheres, classification of surfaces, Brouwer Fixed-point Theorem and Lefschetz Fixed-point Theorem.

**MA5210 Differentiable Manifolds**

*Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA3209 or MA3215 or MA3251 or MA4266 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil*

This module studies differentiable manifolds and the calculus on such manifolds. It covers the following topics: tangent spaces and vector fields in $\mathbb{R}^n$, the Inverse Mapping Theorem, differential manifolds, diffeomorphisms, immersions, submersions, submanifolds, tangent bundles and vector fields, cotangent bundles and tensor fields, tensor and exterior algebras, orientation of manifolds, integration on manifolds, Stokes’ theorem. The course is for mathematics graduate students with interest in topology or geometry. 

(Formerly MA5210 Calculus on Manifolds)

**MA5211 Lie Theory**

*Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA3201 or MA5203 or MA5218 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil*

This module studies Lie groups/algebras and their finite dimensional representations. It covers the following topics: Lie groups and Lie algebras, maximal tori, Weyl group, root systems and Dynkin diagram, structure of (compact) semisimple Lie groups/algebras representations, highest weight theory and Weyl character formula. The course is suitable for graduate students with interest in number theory, representation theory, topology or geometry.

**MA5213 Advanced Partial Differential Equations**

*Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA4221 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil*

This module is an advanced course on partial differential equations. It covers the following topics: the Laplace equations, subharmonic functions, Dirichlet and Neumann problems, the Poisson equations, hyperbolic equations, Cauchy problems, mixed boundary value problems, parabolic equations, initial value problems, maximum principle, mixed boundary value problems. The course is for mathematics graduate students with interest in differential equations and its applications.  

(Formerly MA5213 Partial Differential Equations II)
MA5216 Differential Geometry
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA5210 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

The module is a course on differential geometry aimed at students who have had some exposure to differentiable manifolds. Major topics include: Riemannian metrics, connections, curvatures, warped products, Hyperbolic spaces, metrics on Lie Groups, Riemannian submersions, geodesic and distance, sectional curvature comparison, Killing fields, Hodge Theory, harmonic forms, curvature tensors, curvature operators.

MA5217 Graduate Complex Analysis
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Departmental approval
Preclusion(s): MA4247
Cross-listing(s): Nil

This module is intended to be a rigorous introduction to the study of functions of one complex variable, aimed at the first year graduate level. Major topics: Holomorphic functions, Cauchy’s integral formula and applications, residue and poles, Argument Principle, Maximal Modulus Principle and the Schwarz Lemma, conformal mappings, harmonic functions and analytic continuation.

MA5218 Graduate Algebra IIB
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA5203 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is an introduction to representation theory of finite groups and other related topics. The first third of the course is devoted to the study of semisimple rings and algebras, culminating in the Wedderburn-Artin structure theorem. The remainder of the course is devoted to representation theory of finite groups, character theory and applications such as Burnside’s theorem. If time permits, further topics may be discussed, such as Artin’s and Brauer’s theorems, rationality questions or representations of compact groups.

MA5219 Logic and Foundation of Mathematics I
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA4207 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
This module is designed for graduate students in mathematics, and students in computer science and philosophy who have sufficient mathematical background. The core of the module is Gdels incompleteness theorem. Before that, some basic knowledge on first order logic, such as compactness theorem and properties of reducts of number theory, will be discussed. After that, some basic topics in Recursion Theory and Model Theory are introduced.

**MA5220 Logic and Foundation of Mathematics II**
Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA3205 and MA4207, or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in mathematics, and students in computer science and philosophy who have sufficient mathematical background. The course will be devoted to prove the consistency and independence of Continuum Hypothesis (CH) as well as Axiom of Choice. The topics include Gdels constructible universe and Cohens forcing method. This course will provide the students not only some basics in modern Set Theory, but also deeper understanding of fundamental phenomena in logic, such as constructibility and independence.

**MA5232 Modelling and Numerical Simulations**
Modular Credits: 4  
Workload: 3-0-0-2-5  
Prerequisite(s): Nil  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in mathematics. It focuses on modelling problems in real life and other disciplines into mathematical problems and simulating their solutions by scientific computing methods. Major topics covered include modelling and numerical simulations in selected areas of physical and engineering sciences, biology, finance, imaging and optimisation.

**MA5233 Computational Mathematics**
Modular Credits: 4  
Workload: 3-0-2-2-3  
Prerequisite(s): MA3228 or MA4255 or MA4230 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module studies computational methods in mathematics. It covers the following topics: computational linear algebra, numerical solution of ordinary and partial differential equations, parallel algorithms. The course is for mathematics graduate students with interest in computation methods.
MA5235 **Advanced Graph Theory**
Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA4235 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is an advanced course on graph theory. It covers the following topics: Ramsey theory, extremal graphs, matroids, integer flows and covering, graphs and matrices, random graphs, random walks on graphs. The course is for mathematics graduate students with interest in graph theory and its applications.

MA5236 **Homology Theory**
Modular Credits: 4  
Workload: 3-0-0-2-5  
Prerequisite(s): MA5209 and MA5210 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in mathematics. It covers the following major topics: Homological algebra: categories and functors, chain complexes, homology, exact sequences, Snake Lemma, Mayer-Vietoris, Künneth Theorem. Homology theory: Eilenberg-Steenrod homology axioms, singular homology theory, cellular homology, cohomology, cup and cap products, applications of homology (Brouwer fixed-point theorem, vector fields on spheres, Jordan Curve Theorem), H-spaces and Hopf algebra. Manifolds: de Rham cohomology, orientation, Poincaré duality.

MA5238 **Fourier Analysis**
Modular Credits: 4  
Workload: 3-0-0-3-4  
Prerequisite(s): MA3266 or MA3266S or MA5205 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in mathematics. It covers the following major topics: Fourier series, Fourier transform on R^n, distributions and generalised functions, Sobolev spaces and their applications to partial differential equations. Introduction to singular integrals.

MA5240 **Finite Element Method**
Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA5233 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module studies the finite element method. It covers the following topics: variational principles, weak solutions of differential equations, Galerkin/Ritz method, Lax-Milgram theorem, finite element spaces, stiffness matrices. Shape functions, Barycentric coordinates, numerical integration in R^n, calculation of
stiffness matrices, constraints and boundary conditions, iterative methods and approximate solutions, error estimates. The course is for mathematics graduate students with interest in finite element method and its applications.

(Formerly MA4231 Finite Element Method)

**MA5241 Computational Harmonic Analysis**

Modular Credits: 4  
Workload: 3-0-0-3-4  
Prerequisite(s): MA4229 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in applied mathematics and other related disciplines in science and engineering. It covers the following topics: discrete wavelet transform, discrete wavelet frame and tight frame, sparse approximation in redundant systems, variational methods for ill-posed inverse problems, sampling theory, compressed sensing, low rank matrix approximation, and non-local image restoration approaches.

**MA5242 Wavelets**

Modular Credits: 4  
Workload: 3-0-0-3-4  
Prerequisite(s): MA4229  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is a course focusing on the theory of wavelets and frames. It covers the following topics: Gabor transform and continuous wavelet transform, Gabor frame and wavelet frame, multi-resolution analysis, tight wavelet frame and orthonormal wavelet basis, applications of wavelet and frame in signal/image processing. The course is for graduate students who are interested in the theory or applications of wavelets and frames.

**MA5243 Advanced Mathematical Programming**

Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA3236 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in mathematics. It covers the following major topics: Introduction to convex analysis; Theory of constrained optimisation; Lagrangian duality; Algorithms for constrained optimisation, in particular, penalty, barrier and augmented Lagrangian methods; Interior-point methods for convex programming, in particular, linear and semidefinite programming.
**MA5244 Advanced Topics in Operations Research**

Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): Variable, depending on choice of topics or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is an advanced course on operations research. It covers topics which will be chosen from the following: Large-scale linear and nonlinear programming; Global Optimisation; Variational inequality problems; NP-hard problems in combinatorial Optimisation; Stochastic programming; Multi-objective mathematical programming. The course is for mathematics graduate students with interest in operations research.

**MA5245 Advanced Financial Mathematics**

Modular Credits: 4  
Workload: 3-0-0-1-6  
Prerequisite(s): MA4269 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for honours students in the Quantitative Finance programme and post-graduate students in mathematical finance or quantitative finance. It aims to further students’ understanding in various areas of financial mathematics. Topics include selected materials in the following aspects: Stochastic analysis, stochastic control, and partial differential equations with applications in financial mathematics, exotic options, bond and interest rate models, asset pricing, portfolio selection, Monte Carlo simulation, credit risk analysis, risk management, incomplete markets.

**MA5247 Computational Methods in Finance (Defunct wef Semester 1, AY2017/2018)**

Modular Credits: 4  
Workload: 3-0-0-3-4  
Prerequisite(s): MA2213 and MA3245  
Preclusion(s): QF4102  
Cross-listing(s): Nil

This module is designed for postgraduate students in Mathematical Finance or Quantitative Finance. Students are expected to understand, by course and project work, the procedures, computing efficiency and practical challenges of the numerical methods taught and to be able to tailor them to real-life problems arising in finance. Major topics cover the state-of-the-art knowledge and skills of computational methods for derivative pricing and hedging, financial model calibration, VaR analysis and other aspects of investment and risk management with emphases on lattice, finite-difference and Monte-Carlo methods.
MA5248 Stochastic Analysis in Mathematical Finance
Modular Credits: 4
Workload: 3-0-0-1-6
Prerequisite(s): MA3245 or MA4262 or MA4269 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

Description: This module introduces the basic techniques in stochastic analysis as well as their applications in mathematical finance. Major topics: Brownian motion, stochastic calculus, stochastic differential equations, mathematical markets, arbitrage, completeness, optimal stopping problems, stochastic control, risk-neutral pricing, and generalised Black-Scholes models.

MA5250 Computational Fluid Dynamics
Modular Credits: 4
Workload: 3-0-0-2-5
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is designed for graduate students in mathematics. It focuses on high-resolution numerical methods and their analysis and applications in computational fluid dynamics. It covers the following major topics: Hyperbolic conservation laws and shock capturing schemes, convergence, accuracy and stability, high-resolution methods for gas dynamics and Euler equations, applications in multi-phase flows and combustion.

MA5251 Spectral Methods and Applications
Modular Credits: 4
Workload: 3-0-0-2-5
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is designed for graduate students in mathematics. It focuses on some basic theoretical results on spectral approximations as well as practical algorithms for implementing spectral methods. It will specially emphasise on how to design efficient and accurate spectral algorithms for solving PDEs of current interest. Major topics covered include: Fourier-spectral methods, basic results for polynomial approximations, Galerkin and collocation methods using Legendre and Chebyshev polynomials, fast elliptic solvers using the spectral method and applications to various PDEs of current interest.

MA5252 Methods of Applied Mathematics
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA4221 or MA4252 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

[Items in DARK RED denote changes from this academic year]
This module is intended for graduate students interested in pursuing research in applied and computational mathematics. It provides a concise and self-contained introduction to important methods used in applied mathematics, especially in the asymptotic analysis of differential equations involving multiple scales. Major topics include scaling analysis, perturbation methods, the WKB method, the averaging method, multi-scale expansion and the method of homogenization.

MA5253 Riemann Surfaces  
Modular Credits: 4  
Workload: 3-0-0-7  
Prerequisite(s): MA4247 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil  

This course will be an introduction to Riemann surfaces, focusing on topics such as topology of Riemann surfaces, divisors and line bundles, differential forms and Hodge theory, the Riemann-Roch theorem, period mappings, the Poincaré-Koebe uniformisation theorem. We will also discuss more advanced topics such as algebraic curves, hyperbolic geometry and discrete groups of automorphisms.

MA5259 Probability Theory I  
Modular Credits: 4  
Workload: 3-0-0-7  
Prerequisite(s): MA3207H or MA3207 or MA4262 or departmental approval  
Preclusion(s): ST4237, ST5214  
Cross-listing(s): Nil  

This module studies the theory of probability. It covers the following topics: probability space, weak law of large numbers, strong law of large numbers, convergence of random series, zero-one laws, weak convergence of probability measures, characteristic function, central limit theorem. The course is for graduate students with interest in the theory of probability.

MA5260 Probability Theory II  
Modular Credits: 4  
Workload: 3-0-0-7  
Prerequisite(s): MA5259 or ST5214 or departmental approval  
Preclusion(s): ST5205  
Cross-listing(s): Nil  

The objective of this course to introduce students the basics of Brownian motion and martingale theory. For Brownian motion, we cover topics such as existence and uniqueness of Brownian motion, Skorokhod embedding, Donsker’s invariance principle, exponential martingales associated with Brownian motion, sample path properties of Brownian motion. As for martingales, we confine ourselves to discrete time parameter martingales and cover topics such as conditional expectations and their properties, martingales (submartingales and supermartingales), previsible processes, Doob’s upcrossing lemma, Doob’s martingale convergence theorem, stopping times, martingale transforms and Doob’s optional sampling theorems, martingale inequalities and inequalities for martingale transforms.
MA5261 Applied Stochastic Processes
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA3238 or ST3236
Preclusion(s): Nil
Cross-listing(s): Nil

This module is a course on stochastic processes and their applications. It covers topics in stochastic processes emphasising applications, branching processes, point processes, reliability theory, renewal theory. The course is for graduate students with interest in the applications of stochastic processes.

MA5262 Stochastic Operations Research Models
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA3237 or MA3253
Preclusion(s): Nil
Cross-listing(s): Nil

This module studies stochastic operations research models. It covers the following topics: stochastic dynamic programming, reliability theory, selected topics in inventory theory, selected topics in queuing theory. The course is for graduate students with interest in operations research.

MA5264 Computational Molecular Biology II
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): MA3259
Preclusion(s): Nil
Cross-listing(s): Nil

The course is for graduate students with interest in computational molecular biology. The objective is to develop knowledge and research ability in the subject. This module studies computational biology problems, along with both algorithmic and statistical approaches. It covers different methods for multiple sequence alignment, genome sequencing, comparative analysis of genome information, gene prediction, finding signals in DNA, phylogenetic analysis, protein structure prediction. Other topics covered include micro-array gene expression analysis and computational proteomics.

MA5265 Advanced Numerical Analysis
Modular Credits: 4
Workload: 3-1-0-0-6
Prerequisite(s): (MA2101 or MA2101S) and MA2213
Preclusion(s): Nil
Cross-listing(s): Nil


**MA5266 Optimization**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA2101  
Preclusion(s): Nil  
Cross-listing(s): Nil


**MA5267 Stochastic Calculus**
Modular Credits: 4  
Workload: 3-1-0-0-6  
Prerequisite(s): MA5260 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil


**MA5268 Theory and Algorithms for Nonlinear Optimization**
Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA3252 Linear and Network Optimisation or BDC6111/IE6001 Foundations on Optimization  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module provides a comprehensive introduction to the basic theory and algorithms for nonlinear optimization problems with polyhedral and non-polyhedral constraints. Major topics to be covered include: smooth optimization, constraint qualifications, second order necessary and sufficient conditions, composite nonsmooth optimization, first and second order methods for large scale problems.

[Items in DARK RED denote changes from this academic year]
MA5269 Optimal Stopping and Stochastic Control in Finance
Modular Credits: 4
Workload: 3-0-0-5-2
Prerequisite(s): Departmental approval for non-PhD students
Preclusion(s): Nil
Cross-listing(s): Nil

This module covers the fundamental theory of optimal stopping and stochastic control. Two typical examples arising from finance will be elaborated: American option pricing and portfolio selection. Major topics include optimal stopping problems, stochastic control problems, HJB equations, viscosity solution, variational inequality equations, etc.

MA5295 Dissertation for M.Sc. by Coursework
Modular Credits: 8
Workload: 0-0-0-20-0
Prerequisite(s): Departmental approval (for students in 2006/07 and later cohorts who are enrolled in M.Sc. in Mathematics by course work)
Preclusion(s): Nil
Cross-listing(s): Nil

Student is expected to conduct research on a topic or area in mathematics, write a report and give an oral presentation on it.

MA5296 Mathematics Seminar I (Defunct wef Semester 1, AY2017/2018)
Modular Credits: 4
Workload: 2-0-0-1-7
Prerequisite(s): Departmental approval (for students in 2006/07 and later cohorts who are enrolled in M.Sc. in Mathematics by course work).
Preclusion(s): Nil
Cross-listing(s): Nil

A theme or one or several topics in mathematics, which may vary from semester to semester, will be chosen by the lecturer-in-charge or students enrolled in the module. Students will make an in-depth study of the topics chosen and take turns to give seminar presentations on the chosen topics. Students will also be required to provide verbal critique and submit written reports on selected presentations.

MA5297 Mathematics Seminar II (Defunct wef Semester 1, AY2017/2018)
Modular Credits: 4
Workload: 2-0-0-1-7
Prerequisite(s): Departmental approval (for students in 2006/07 and later cohorts who are enrolled in M.Sc. in Mathematics by course work).
Preclusion(s): Nil
Cross-listing(s): Nil

A theme or one or several topics in mathematics, which may vary from semester to semester, will be chosen by the lecturer-in-charge or students enrolled in the module. Students will make an in-depth study of the
topics chosen and take turns to give seminar presentations on the chosen topics. Students will also be required to provide verbal critique and submit written reports on selected presentations.

**MA6201 Topics in Algebra and Number Theory I**
- Modular Credits: 4
- Workload: 3-0-0-0-7
- Prerequisite(s): Departmental approval
- Preclusion(s): Nil
- Cross-listing(s): Nil

Selected topics in algebra and number theory are offered.

**MA6202 Topics in Algebra and Number Theory II**
- Modular Credits: 4
- Workload: 3-0-0-0-7
- Prerequisite(s): Departmental approval
- Preclusion(s): Nil
- Cross-listing(s): Nil

Selected topics in algebra and number theory are offered.

**MA6205 Topics in Analysis I**
- Modular Credits: 4
- Workload: 3-0-0-0-7
- Prerequisite(s): Variable, depending on choice of topics or departmental approval
- Preclusion(s): Nil
- Cross-listing(s): Nil

Selected topics in real analysis, complex analysis, Fourier analysis, functional analysis, operator theory and harmonic analysis are offered.

**MA6206 Topics in Analysis II**
- Modular Credits: 4
- Workload: 3-0-0-0-7
- Prerequisite(s): Departmental approval
- Preclusion(s): Nil
- Cross-listing(s): Nil

Selected topics in real analysis, complex analysis, Fourier analysis, functional analysis, operator theory and harmonic analysis are offered.
MA6211 Topics in Geometry and Topology I
Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

Selected topics in differential geometry, algebraic geometry and topology are offered.

MA6212 Topics in Geometry and Topology II
Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

Selected topics in differential geometry, algebraic geometry and topology are offered.

MA6215 Topics in Differential Equations
Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

Selected topics in ordinary differential equations and partial differential equations are offered.

MA6216 Advanced Dynamical Systems
Modular Credits: 4  
Workload: 3-0-0-0-7  
Prerequisite(s): MA4233 or departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is an advanced course on dynamical systems. It covers the following topics:  
Ergodic theorems, invariant measures, mixing, chaos, attractors, fractals, topological entropy, metric entropy, Lyapounov exponents, hyperbolic dynamical systems, symbolic dynamics, dynamics of flows, complex dynamics, group actions. The course is for mathematics graduate students with interest in dynamical systems.
MA6217 Homotopy Theory
Modular Credits: 4
Workload: 3-0-0-2-5
Prerequisite(s): MA5236 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
This module is designed for graduate students in mathematics. It covers the following major topics: Homotopy theory: homotopy groups, fibrations, Hurewicz Theorem, Whitehead Theorem, Postnikov systems and Eilenberg-MacLane spaces, simplicial homotopy theory, simplicial groups, James construction, Hopf invariants, Whitehead products, Hilton-Milnor Theorem, cohomology operations and the Steenrod algebra. Homology theory: homology of fibre spaces and Leray-Serre spectral sequences. Geometry: homotopy and homology of Lie groups and Grassmann manifolds, fibre bundles.

MA6219 Recursion Theory
Modular Credits: 4
Workload: 3-0-0-2-5
Prerequisite(s): MA5219 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
This module is designed for graduate students in mathematics who are interested in mathematical logic. It consists of the following parts: (a) background knowledge in recursion theory; (b) basic techniques in degree theory, such as forcing and priority methods; (c) some generalisations and applications of recursion theory.

MA6220 Model Theory
Modular Credits: 4
Workload: 3-0-0-2-5
Prerequisite(s): MA5219 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
This module is designed for graduate students in mathematics, who have sufficient background in mathematical logic. The course will be structured around Morley’s Categoricity Theorem. To set up the stage of the proof of Morley’s Theorem, some necessary knowledge is also introduced, which turns out to be a good training in model theory.

MA6221 Topics in Combinatorics
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
Selected topics in combinatorics and graph theory are offered.
MA6222 Set Theory I
Modular Credits: 4
Workload: 3-0-0-2-5
Prerequisite(s): MA5219 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
This module is designed for graduate students in mathematics, who are interested in set theory. It consists of the following four parts: The Singular Cardinal problem and Silver’s Theorem; Shelah’s Possible Cofinality Theory; Supercompact Cardinals and Solovay’s Theorem; Negative solutions of SCH from large cardinals; Positive solutions from Forcing Axioms.

MA6223 Set Theory II
Modular Credits: 4
Workload: 3-0-0-2-5
Prerequisite(s): MA6222 or departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
This module is designed for graduate students in mathematics, who are interested in set theory. It focuses mainly on inner models, their covering properties, and their applications to give lower bounds of the negation of SCH.

MA6225 Topics in Coding Theory and Cryptography
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
Selected topics in coding theory and cryptography are offered.

MA6235 Topics in Financial Mathematics
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil
Selected topics in financial mathematics are offered.
MA6241 Topics in Numerical Methods
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

Topics offered will be of advanced mathematical nature and will be selected by the Department.

MA6251 Topics in Applied Mathematics I
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

Topics offered will be of advanced mathematical nature and will be selected by the Department.

MA6252 Topics in Applied Mathematics II
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil

Topics offered will be of advanced mathematical nature and will be selected by the Department.

MA6253 Conic Programming
Modular Credits: 4
Workload: 3-0-0-3-4
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is designed for graduate students in mathematics whose research areas fall within optimisation and operations research. It focuses on fundamental theory and algorithms for linear and nonlinear conic programming problems. Major topics covered include first order optimality conditions, second order necessary and sufficient conditions, sensitivity and perturbation analysis, and design and convergence analysis and various Newton’s methods.

MA6291 Topics in Mathematics I
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

Topics offered will be of advanced mathematical nature and will be selected by the Department.

**MA6292 Topics in Mathematics II**
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

Topics offered will be of advanced mathematical nature and will be selected by the Department.

**MA6293 Topics in Mathematics III**
Modular Credits: 4
Workload: 3-0-0-0-7
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

Topics offered will be of advanced mathematical nature and will be selected by the Department.

**QF3101 Investment Instruments: Theory and Computation**
Modular Credits: 4
Workload: 3-1-0-2-4
Prerequisite(s): (MA1104 or MA1505 or MA1507 or MA1511 or MA2104) and (MA2222 or QF2101 or MA3269)
Preclusion(s): Nil
Cross-listing(s): Nil

The module aims to present the student with the basic paradigms of modern financial investment theory, to provide a foundation for analysing risks in financial markets and to study the pricing of financial securities. Topics will include the pricing of forward and futures contracts, swaps, interest rate and currency derivatives, hedging of risk exposures using these instruments, option trading strategies and value-at-risk computation for core financial instruments. A programming project will provide students with hands-on experience with real market instruments and data. This module targets all students who have an interest in quantitative finance.

**QF3201 Basic Derivatives and Bonds**
Modular Credits: 4
Workload: 3-0.5-1-2.5-3
Prerequisite(s): FIN2004
Preclusion(s): Nil
Cross-listing(s): Nil

The aim of this course is to enable students to acquire the financial domain knowledge in computational finance. Through computer-based exercise and laboratory work, students will acquire the quantitative tools
in derivatives and bonds used by the finance industry. Topics will include Derivative Instruments and their applications, Bonds, Bonds Analytics, Fixed Income Derivatives, Risk Management using Fixed Income Derivatives and Credit Derivatives. This course targets all students who have an interest in computational finance.

**QF4102 Financial Modelling and Computation (only for MSc QF students)**

Modular Credits: 4  
Workload: 3-1-0-2-4  
Prerequisite(s): QF3101  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module aims to present students with the knowledge of modelling financial process for the purpose of pricing financial derivatives, hedging derivatives, and managing financial risks. The emphasis of this module will be on numerical methods and implementation of models. The course will have two basic elements. First, course work with topics includes: implied trinomial trees, finite difference lattices, Monte Carlo methods, model risk, discrete implementations of short rate models, credit risk and value-at-risk. The second element of the course will be a group project to develop a financial modelling tool. Project topics will be extensions of models contained in the course work. Projects will involve financial modelling as well as writing and presenting a project report. This module targets students in the Quantitative Finance programme.

**QF4199 Honours Project in Quantitative Finance**

Modular Credits: 12  
Workload: 0-0-0-30-0  
Prerequisite(s): Only for students majoring in Quantitative Finance and who matriculated from 2004/05, subject to faculty and departmental requirements.  
Preclusion(s): Nil  
Cross-listing(s): Nil

The Honours project is intended to give students the opportunity to work independently, to encourage students develop and exhibit aspects of their ability not revealed or tested by the usual written examination, and to foster skills that could be of continued usefulness in their subsequent careers. The project work duration is one year (including assessment).

**QF5201 Interest Rate Theory and Credit Risk (only for MSc QF students)**

Modular Credits: 4  
Workload: 3-0-0-1-6  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in quantitative finance. It focuses on advanced topics in interest rate theory and credit risk modelling and emphasizes their analogies. The module covers the following major topics. Products of fixed-income markets, Short rate models, Heath-Jarrow-Morton framework, LIBOR model models. Financial instruments in credit risk management, Models of default: Firm value and first passage time models, intensity based models, models of credit rating migrations. The module also provides a discussion of
advantages and shortcomings of synthetic credit-linked instruments; moreover, modeling dependence structure of default events and default contagion will be discussed.

**QF5202 Structured Products (only for MSc QF students)**

Modular Credits: 4  
Workload: 3-0-0-3-4  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in quantitative finance. It covers the valuation of various structured products in the financial markets, including convertible bonds, mortgage backed securities, annuity products in insurance, real options, volatility swaps, collateralized debt obligations. Numerical methods and implementations will be discussed.

**QF5203 Risk Management (only for MSc QF students)**

Modular Credits: 4  
Workload: 3-0-0-3-4  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This graduate module on quantitative finance provides a study of the nature, measurement, analysis of, and management of different types of financial risks, including market risk, credit risk, operational risk, liquidity and model risks. It develops the mathematical fundamentals and models for risk management, including a general framework of risk and credit measures, dynamic analysis of financial derivative parameters (Greeks) and their changes in real-time for trading risk management. Examples from current and/or past developments in financial markets will be chosen to provide illustrations so that students may understand the various types of risk and learn the methods to handle the management of risks.

**QF5204 Numerical Methods in Quantitative Finance (only for MSc QF students)**

Modular Credits: 4  
Workload: 3-0-0-3-4  
Prerequisite(s): Departmental approval  
Preclusion(s): Nil  
Cross-listing(s): Nil

This module is designed for graduate students in quantitative finance. It covers the programming methodology, techniques, data structures and algorithms used by practitioners in finance in the valuation of investment instruments. Numerical methods and implementations will be discussed.
QF5205 Topics in Quantitative Finance I (only for MSc QF students)
Modular Credits: 4
Workload: 3-0-0-3-4
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is designed for graduate students in quantitative finance. The objective is to offer topics in quantitative finance that are of current interest and not covered by other modules in the quantitative finance programme, with the aim of providing students with the knowledge and skills that are of current demand in the finance industry. The module demonstrates how various mathematical concepts and methods in disciplines such as stochastic analysis, stochastic control, partial differential equations and numerical methods that the students have learned in the other modules are used to solve practical problems in quantitative finance, and emphasizes mathematical modeling, algorithms and numerical implementation. The topics covered may vary from year to year, and will be decided by the lecturer.

QF5206 Topics in Quantitative Finance II (only for MSc QF students)
Modular Credits: 4
Workload: 3-0-0-3-4
Prerequisite(s): Departmental Approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is designed for graduate students in quantitative finance. The objective is to offer topics in quantitative finance that are of current interest and not covered by other modules in the quantitative finance programme, with the aim of providing students with the knowledge and skills that are of current demand in the finance industry. The module demonstrates how various mathematical concepts and methods in disciplines such as stochastic analysis, stochastic control, partial differential equations and numerical methods that the students have learned in the other modules are used to solve practical problems in quantitative finance, and emphasizes mathematical modeling, algorithms and numerical implementation. The topics covered may vary from year to year, and will be decided by the lecturer.

QF5207 Investment and Portfolio Selection (only for MSc QF students)
Modular Credits: 4
Workload: 3-0-0-5-2
Prerequisite(s): Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module is designed for graduate students in quantitative finance. The topics include measuring risk and return, the Markowitz’s mean-variance analysis, the continuous time portfolio selection theory, the capital asset pricing model, and the arbitrage pricing theory. The module will also touch optimization theory and stochastic control.
QF5210 Financial Time Series: Theory and Computation
Modular Credits: 4
Workload: 3-1-0-2-4
Prerequisite(s): (QF3101 and MA4269) or Departmental approval
Preclusion(s): Nil
Cross-listing(s): Nil

This module introduces students to financial time series techniques, focusing primarily on Box-Jenkins (ARIMA) method, conditional volatility (ARCH/GARCH models), stochastic volatility models, regime switching and nonlinear filtering, diverse non-linear state models, co-integration, and their applications on real-life financial problems. We provide both the relevant time series concepts and their financial applications. Potential application of financial time series models include modeling equity returns, volatility estimations, Value at Risk modelling and option valuation. This module targets honours students in the Quantitative Finance Programme and students in the Master of Science in Quantitative Finance Programme.