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Course Regulations for Year 1 - 2022/3 Onwards

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/)

The below reflects the new curriculum introduced for the 2022/23 academic year. For students who commenced studies before the 2022/23 first year regulations can be found archived here.

MATHEMATICS BSC. G100, MASTER OF MATHEMATICS MMATH G103, MATHEMATICS WITH BUSINESS STUDIES G1NC.

Normal Load = 120 CATS. Maximum Load = 150 CATS.

Students must take the 9 core modules (total 100 CATS), plus options. The Core modules are: MA132 Foundations, MA141 Analysis 1, MA139 Analysis 2, MA151 Algebra 1, MA150 Algebra 2, MA146 Methods of Mathematical Modelling 1, MA144 Methods of Mathematical Modelling 2, MA124 Mathematics By Computer, ST120 Introduction to Probability.

MATHEMATICS AND ECONOMICS GL11

The first year is in common with the BSc Mathematics degree course G100, with the addition of EC107 Economics I as an additional core module (total core of 130 CATS). For students on G100 and G103 who wish to transfer to GL11 at the end of the year, you must take EC106 which can be substituted for EC107.

Note. Choosing options is discussed here.

Of the core, the modules MA139 Analysis 2, MA146 Methods of Mathematical Modelling 1, MA144 Methods of Mathematical Modelling 2 and MA150 Algebra 2 are designated as being "required cores". This means that all first years **must** pass these modules (at 40%) either in the Summer exams or the resit exams the following September, in order to progress in to the second year, alongside getting an overall 40% for the year and passing at least 90 CATS of modules.

GL11 students must in addition pass EC107.

MA141 Analysis 1 has an exam in January. In general, for the other maths modules Term 1 modules are examined in April/May straight after the Easter Vacation and Term 2 modules later in Term 3 (June).

Additional advice to first year students

Maths Modules

Term	Code	Module	CATS	List
Pre-Term	MA1K2	Refresher Mathematics	0	Core
Term 1	MA132	Foundations	10	Core
	MA141	Analysis 1	10	Core
	MA146	Methods of Mathematical Modelling 1	10	Core
	MA151	Algebra 1	10	Core
Term 1 & 2	MA124	Maths by Computer	10	Core
Term 2	MA139	Analysis 2	15	Core
	MA144	Methods of Mathematical Modelling 2	10	Core
	MA150	Algebra 2	15	Core
	MA117	Programming for Scientists	10	List B

Maths Modules for External Students

These modules are not available to Maths students.

Term	Code	Module	CATS
Term 1	MA138	Sets and Numbers	10
	MA140	Mathematical Analysis 1	10
	MA142	Calculus 1	10
	MA147	Mathematical Methods and Modelling 1	10

Term 2	MA133	Differential Equations	10
	MA152	Mathematical Analysis 2	15
	MA143	Calculus 2	10
	MA145	Mathematical Methods and Modelling 2	10
	MA149	Linear Algebra	15
	MA148	Vectors and Matrices	10

Statistics Modules

For those interested in probability and statistics modules, please see the Studying Probability and Statistics for further information.

First year mathematics students interested in transferring to MORSE (Mathematics, Operational Research, Statistics and Economics) should include the following modules among their options

EC106 Introduction to Quantitative Economics(30 CATS, Terms 1-2);
IB104 Mathematical Programming I (7.5 CATS version, Term 3);
ST121 Statistical Laboratory (10 CATS, Term 2)

This would allow transfer into the second year of MORSE, which consists of roughly equal proportions from the four participating departments (Statistics, Economics, Business Studies and Mathematics). Further details of MORSE can be obtained from the Statistics Department.

For transfer into Mathematics and Statistics students should take

ST121 Statistical Laboratory (10 CATS, Term 2)

Transfer into any Statistics course will depend on available capacity and is likely to be restricted to only the strongest students.

Term	Code	Module	CATS	List
Term 1	ST120	Introduction to Probability	10	Core
Term 2	ST121	Statistical Laboratory	10	List B

Economics Modules

Mathematics & Economics (GL11) students should refer to the Economics Undergraduate handbook and to the section on joint degree courses in this handbook.

Other mathematics students (G100 or G103, BSc or MMath) may take EC106 Introduction to Qualitative Economics as an option. [Note: Maths & Economics students do NOT take EC106.] It is designed to be suitable for Mathematics students, and a good performance in this module >55% is a prerequisite for some optional second and third year Economics modules. See the Economics Department Undergraduate handbook, which also contains details of other more specialized first year economics options. **If you wish to take second year Economics modules next year then you MUST take EC106 or EC107 this year,**

Term	Code	Module	CATS	List
Terms 1 & 2	EC106	Introduction to Quantitative Economics	30	List B (not GL11)
	EC107	Economics I	30	Core (GL11 only)

Computer Science

Mathematics students should note that *at least one 1st year programming module*, or the ability to program in a high level language, *is a prerequisite* for most Computer Science modules in Years 2 and 3. There are two roughly equivalent high level programming modules. CS118 Programming for Computer Scientists which is taken by Computer Science students, and MA117 Programming for Scientists which is available to all Mathematics students as an option. MA117 satisfies the programming prerequisite for Computer Science options.

Students considering transferring to the Discrete Mathematics G4G1 degree should take the modules Discrete Mathematics & its Applications 2 as well as MA117 Programming for Scientists.

Term	Code	Module	CATS	List
Term 2	CS147	Discrete Mathematics & its Applications 2	10	List B

Physics

Physics options for Mathematics students: Weekly problem sheets are issued for all the first year Physics modules. Any combination of Physics options may be taken. However, the Physics Department recommends the following modules and combinations, especially for students who may wish to transfer to the Maths and Physics degree at the end of the first year.

- PX156 Quantum Phenomena. This module deals from first principles with one of the major components of modern Physics. It leads on to several options in 2nd year Physics (see the second year options for details).
- PX155 Classical Mechanics and Special Relativity
- PX157 Electricity and Magnetism. These lectures treat the classical description of the behaviour of particles, waves and matter.

Term	Code	Module	CATS	List
Term 1	PX155	Classical Mechanics and Special Relativity	10	List B
Term 2	PX157	Electricity and Magnetism	10	List B
	PX158	Astronomy	10	List B
	PX156	Quantum Phenomena	10	List B

Philosophy Modules

Students wishing to follow modules in Philosophy should register for these modules at the start of Term 1, using the online registration system.

In order to follow 2nd or 3rd year Philosophy honours modules students must normally first have completed a total of 30 CATS of Philosophy modules at the first year level. Those in doubt should consult the module tutor of the relevant module.

Students on the Mathematics and Philosophy joint degree take the following two modules in their first year: PH142 Central Themes in Philosophy (term 2); PH136 Logic I: Introduction to Symbolic Logic (term 2). Mathematics students are also eligible for a transfer to Mathematics and Philosophy if they take the same module combination in their first year. See the Philosophy Department's website

Term	Code	Module	CATS	List
Term 1	PH144	Mind and Reality	15	List B
	PH146	Reason, Argument and Analysis	15	List B
Term 2	PH136	Logic I: Introduction to Symbolic Logic	15	List B

Warwick Business School

See Information for all WBS modules.

Note that for any WBS module you MUST register on both the University registration system (eVision) and the WBS system (MyWBS), **with the same CATS weighting**. Failure to do this may mean that you will not be permitted to continue on the module and be removed from it.

Term	Code	Module	CATS	List
Term 3	IB104	Mathematical Programming I	10	List B

Languages

The Language Centre offers academic modules in Arabic, Chinese, French, German, Japanese, Russian and Spanish at a wide range of levels. These modules are available for exam credit as unusual options to mathematicians in all years. Pick up a leaflet listing the modules from the Language Centre, on the ground floor of the Humanities Building by the Central Library. Full descriptions are available on request. Note that you may only take one language module (as an Unusual Option) for credit in each year. Language modules are available as whole year modules, or smaller term long modules; both options are available to maths students. These modules may carry 24 (12) or 30 (15) CATS and that is the credit you get. We used to restrict maths students to 24 (12) if there was a choice, but we no longer do this.

Plan ahead! Note that 3rd and 4th year students cannot take beginners level (level 1) Language modules.

There is also an extensive and very popular programme of lifelong learning language classes provided by the centre to the local community, with discounted fees for Warwick students. Enrolment is from 9am on Wednesday of week 1. These classes do not count as credit towards your degree.

The Transnational Resources Centre provides resources in the FAB building for all students registered with the Language Centre, more information can be found here.

Important note for students who pre-register for Language Centre modules

It is essential that you confirm your module pre-registration by coming to the Language Centre as soon as you can during week one of the new academic year. If you do not confirm your registration, your place on the module cannot be guaranteed. If you decide, during the summer, NOT to study a language module and to change your registration details, please have the courtesy to inform the Language Centre of the amendment.

Information on modules can be found at

http://www2.warwick.ac.uk/fac/arts/languagecentre/academic/

Engineering

Mathematics students interested in taking Engineering modules in later years should see the page for year 2 and 3 modules for any prerequisites. Details of all engineering modules can be found on the Engineering web pages.

Objectives

After completing the first year students will have

- made the transition in learning style and pace from school to university mathematics;
- been introduced to the basic concepts in university mathematics, in particular proof, rigour and calculations;
- begun the study of the foundational core;
- acquired knowledge, understanding and techniques necessary to proceed to the second year.

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA1 Template

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma1-template/)
Lecturer: Michael Schenker

Term(s): Term 1

Status for Mathematics students: Core

Commitment: 30 lectures, written assignments

Assessment: 15% from assignments and 85% from Summer exam

Formal registration prerequisites: None

Assumed knowledge: Grade A in A-level Further Maths or equivalent.

Useful background:

Synergies: specifically:

- MA132 Foundations
- MA141 Analysis 1
- MA139 Analysis 2
- MA151 Algebra 1
- MA150 Algebra 2
- MA268 Algebra 3
- MA146 Methods of Mathematical Modelling 1
- MA144 Methods of Mathematical Modelling 2

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

-

Aims: To provide a working understanding of matrices and vector spaces for later modules to build on and to teach students practical techniques and algorithms for fundamental matrix operations and solving linear equations.

Content: Many problems in maths and science are solved by reduction to a system of simultaneous linear equations in a number of variables. Even for problems which cannot be solved in this way, it is often possible to obtain an approximate solution by solving a system of simultaneous linear equations, giving the "best possible linear approximation".

The branch of maths treating simultaneous linear equations is called linear algebra. The module contains a theoretical algebraic core, whose main idea is that of a vector space and of a linear map from one vector space to another. It discusses the concepts of a basis in a vector space, the dimension of a vector space, the image and kernel of a linear map, the rank and nullity of a linear map, and the representation of a linear map by means of a matrix.

These theoretical ideas have many applications, which will be discussed in the module. These applications include:

- Solutions of simultaneous linear equations
- Properties of vectors
- Properties of matrices, such as rank, row reduction, eigenvalues and eigenvectors
- Properties of determinants and ways of calculating them

Objectives: Students must understand the ideas of linearly independent vectors, spanning sets and bases of vector spaces. They must also understand the equivalence of linear maps between vector spaces and matrices and be able to row reduce a matrix, compute its rank and solve systems of linear equations. The definition of a determinant in all dimensions will be given in detail, together with applications and techniques for calculating determinants. Students must know the definition of the eigenvalues and eigenvectors of a linear map or matrix, and know how to calculate them.

Books: The lecture notes will provide comprehensive coverage of the material, but it is all standard foundational mathematics and you can compare how it is covered in many other sources.

David Towers, *Guide to Linear Algebra*, Macmillan 1988.

Howard Anton, *Elementary Linear Algebra*, John Wiley and Sons, 1994.

Paul Halmos, *Linear Algebra Problem Book*, MAA, 1995.

G Strang, *Linear Algebra and its Applications*, 3rd ed, Harcourt Brace, 1988.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA139 Analysis 2

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma139/)
Lecturer: Keith Ball

Term(s): Term 2

Status for Mathematics students: Core

CAUTION: This entry refers to arrangements for students based in the Mathematics Department (those who entered through the Mathematics Department and have a Personal Tutor there). All other students should be registered on MA152 Mathematical Analysis 2.

Commitment: 30 lectures, written assignments

Assessment: Weekly assignments (15%), June exam (85%)

Formal registration prerequisites: None

Assumed knowledge: MA141 Analysis I

Useful background:

Synergies: Analysis is one of the two most fundamental parts of pure mathematics, the other being Algebra. This module and the first term module MA141 Analysis I form the foundation on which many other modules will be built. Amongst the first year modules, the one most closely related is MA141 Analysis I but analysis also has close connections to applied mathematics, probability theory and physics. The most natural synergies are therefore:

- MA141 Analysis 1
- MA144 Methods of Mathematical Modelling 2
- MA146 Methods of Mathematical Modelling 1

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA222 Metric Spaces
- MA260 Norms, Metrics and Topologies
- MA254 Theory of ODEs
- MA259 Multivariable Calculus
- MA4J1 Continuum Mechanics

Aims:

Content:

At the beginning of the nineteenth century, the familiar tools of calculus, differentiation and integration, began to run into problems. Mathematicians were unsure of how to apply these tools to sums of infinitely many functions. The origins of Analysis lie in their attempt to formalize the ideas of calculus purely in the language of arithmetic and to resolve these problems.

You will study ideas of the mathematicians Cauchy, Dirichlet, Weierstrass, Bolzano, D'Alembert, Riemann and others. Following on from the material concerning sequences, series and continuity in term one, you will study differentiation and integration in term two.

By the end of the year you will be able to answer many interesting questions: What do we mean by `infinity'? How can you accurately compute the value of π or e or √2 ? How can you add up infinitely many numbers, or integrate a function?

There will be considerable emphasis throughout the module on the need to argue with much greater precision and care than you had to at school. With the support of your fellow students, lecturers and other helpers, you will be encouraged to move on from the situation where the teacher shows you how to solve each kind of problem, to the point where you can develop your own methods for solving problems. You will also be expected to question the concepts underlying your solutions, and understand why a particular method is meaningful and another not so. In other words, your mathematical focus should shift from problem solving methods to concepts and clarity of thought.

Objectives:

Books:

M. Hart, *Guide to Analysis*, Macmillan. (A good traditional text with theory and many exercises)
K.G. Binmore, *Mathematical Analysis: A Straightforward Approach*, CUP (1982)
R.G Bartle and D.R Sherbert, *Introduction to Real Analysis*, (4th Edition), Wiley (2011)
L. Alcock, *How To Think About Analysis*, Oxford University Press (2014)

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA141 Analysis 1

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma141/)
Lecturer: James Robinson

Term(s): Term 1

Status for Mathematics students: Core

Commitment: 30 lectures, written assignments

Assessment: 85% from January exam and 15% from assignments. Four assignments: mark will be best of three

Formal registration prerequisites: None

Assumed knowledge: Grade A in A-level Further Maths or equivalent

Useful background: None

Analysis and Algebra are the two fundamental areas of pure mathematics. This module forms the foundations for all the following Analysis-based modules. Along with MA139 Analysis 2, the other closely related first-year modules are MA146 Methods of Mathematical Modelling 1 and MA144 Methods of Mathematical Modelling 2.

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

All future Analysis or Analysis-related modules, including the following Year 2 modules:

- MA244 Analysis III
- MA259 Multivariable Calculus
- MA250 Introduction to PDEs
- MA254 Theory of ODEs
- MA260 Norms, Metrics and Topologies
- MA209 Variational Principles

and familiarity with the results (if not the proofs) will be needed in:

- MA261 Differential Equations: Modelling and Numerics
- MA269 Asymptotics and Integral Transforms

Aims: Analysis is the area of mathematics that - among other things - places calculus (differentiation and integration) on a solid foundation. While the Analysis 2 module discusses calculus, Analysis 1 introduces the key ideas and will get you used to producing rigorous arguments.

You will have seen at school how the tangent to a curve as the result of drawing two points on the curve ever closer together; but how do we talk about this in a precise way that then enables us to prove something about its properties?

Content: Analysis 1 covers three main topics, with the first two closely related.

1. Sequences and limits.

We start off by discussing how to define "limits" properly. What does it mean to say that $1/n \to 0$ as $n \to \infty$? With a simple example like this it is easy to have an intuitive idea, but how do we understand the statement that $(1 + \frac{1}{n})^n \to \mathrm{e}$ as $n \to \infty$ or prove that $n^{1/n} \to 1$ as $n \to \infty$? Once we want to prove more interesting things like these, we need a proper definition of what a limit really is.

2. Sums of series.

A very natural way in which such a limiting process arises is if we try to sum up infinite series. What does it mean to say that

$\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \cdots = \sum_{n=1}^{\infty} 2^{-n} = 1$?

This you can see by thinking about cutting a cake in half repeatedly, so once more your intuition will give you an idea. But what about

$1 + \frac{1}{4} + \frac{1}{9} + \cdots = \sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}$?

The first step to proving this (the proof is not easy!) is to understand what such a statement actually means.

3. Continuous functions.

What does it mean for a function to be continuous? (We will first, of course, have to think a little more carefully about what a "function" actually is - although by the time we treat functions in Analysis 1, you will have covered them in Foundations.)

After reading the above, it should be fairly clear that "something you can draw without taking your pencil off the page" is not going to get us very far - certainly not if we want to prove anything!

We will give a formal definition of what it means for a function to be continuous and then use this to prove some basic (and extremely useful) properties of continuous functions. Sometimes the results we prove might seem to be "obvious", but try proving the *Intermediate Value Theorem* below without having a proper definition of what it means to be continuous. ("But it's just obvious!" is not a proof.)

Let $f\colon [a, b] \to \mathbb{R}$ be continuous, and assume that $f(a) < f(b)$. Then for any c with $f(a) < c < f(b)$ there exists a point $x \in (a, b)$ such that $f(x) = c$.

Books:
M. Hart, *Guide to Analysis*, Macmillan. (A good traditional text with theory and many exercises)
K.G. Binmore, *Mathematical Analysis: A Straightforward Approach*, CUP (1982)
L. Alcock, *How To Think About Analysis*, Oxford University Press (2014)

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA144 Methods of Mathematical Modelling 2

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma144/)
Lecturer: Siri Chongchitnan

Term(s): Term 2

Status for Mathematics students: Core

Commitment: 30 lectures, written and online assignments

Assessment: 10% assignments, 5% online quizzes, 85% Summer exam

Formal registration prerequisites: None

Assumed knowledge: Grade A in A-level Further Maths or equivalent

Synergies: Specifically:

- MA132 Foundations
- MA141 Analysis 1
- MA139 Analysis 2
- MA151 Algebra 1
- MA150 Algebra 2
- MA268 Algebra 3
- MA146 Methods of Mathematical Modelling 1

Aims:

This module will show intuitive geometric and physical concepts such as length, area, volume, mass, circulation and flux can be translated into mathematical formulae. Its focus is the practical calculation of these formulae and their application to geometric problems in 2D and 3D.

Content:

We will study parametric curves and surfaces using the tools of *vector calculus*. The bulk of the course content relies on the use of partial differentiation and multiple integrals.

Objectives:

On successful completion of this module students should be able to:

- Parametrise simple curves and surfaces in Cartesian and other coordinates, including polar, cylindrical and spherical coordinates
- Calculate lengths of curves in R^2 and R^3
- Understand and be able to calculate line, surface and volume integrals with respect to various coordinate systems. This includes change of variables and change of order of integration in double/triple integrals

- Understand and prove simple properties of a conservative vector field
- State the Green's, Divergence and Stokes' Theorems and use them to aid calculations
- Apply all these techniques to problems in mechanics (mass, work done, circulation and flux) and geometry (area, volume, centre of mass).

Books: See the reading list on Talis

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA146 Methods of Mathematical Modelling 1

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma146/)
Lecturer: Bjorn Stinner

Term(s): Term 1

Status for Mathematics students: Core

Commitment: 20h lectures, 10h videos and/or handouts, problem sheets

Assessment: 15% from assignments and 85% from April exam

Formal registration prerequisites: None

Assumed knowledge: None (standard entry criteria for Maths students suffice)

Useful background: Modelling with differential equations, solution techniques for linear differential equations of first and second order, eigenvalues and -vectors of 2x2 matrices, python and jupyter notebooks.

Synergies: MA124 Maths by Computer (python programming, problem solving on the computer)

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA144 Methods of Mathematical Modelling 2
- MA265 Methods of Mathematical Modelling 3
- MA250 Introduction to Partial Differential Equations
- MA254 Theory of ODEs
- MA256 Introduction to Mathematical Biology
- MA261 Numerical Methods and Computing
- MA269 Asymptotics and Integral Transforms

Learning Outcomes: By the end of the module students should be able:

- To understand the modelling cycle in science and engineering, to formulate mathematical models and problems using differential equations, and to use a variety of methods to reveal their main underlying dynamics.
- To apply a range of techniques to solve simple ordinary differential equations (first order, second order, first order systems), and to gain insight into the qualitative behaviour of solutions.
- To confidently deploy computational methods and software to validate results, to approximate solutions of more challenging problems, and to further investigate them.

Content:

1. Introduction to mathematical modelling with differential equations: Modelling cycle, principles and observations, types of problems, scaling and dimensional analysis, simplification and reduction, perturbation methods.
2. Intro to differential equations: Classification, general first order equations, autonomous equations, stability, integrating factors for linear equations, separation and substitution methods for nonlinear equations.
3. Systems and higher order equations: Relation between higher order equations as systems, general 2x2 systems, autonomous systems, phase portraits, linearisation and linear stability, general theory for linear systems, eigenspace analysis in case of constant coefficients.
4. Further problems and techniques: a selection from discretisation principles and difference equations, control problems, dynamical systems, attractors and linearisation.

Books:

Robinson, James C. *An Introduction to Ordinary Differential Equations*. Cambridge University Press, 2004.

Witelski, B. and Bowen, M., *Methods of Mathematical Modelling: Continuous Systems and Differential Equations.* Springer, 2015.

Logan, David. *A First Course in Differential Equations*. Springer, 2015.

Holmes, Mark H. *Introduction to the Foundations of Applied Mathematics.* Springer, 2019.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA150 Algebra 2

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma150/)
Lecturer: Gavin Brown

Term(s): Term 2

Status for Mathematics students: Core

Commitment: 30 lectures, written assignments

Assessment: 15% from assignments and 85% from Summer exam

Formal registration prerequisites: None

Assumed knowledge: Grade A in A-level Further Maths or equivalent.

Useful background:

Synergies: this module is most closely related to:

- MA132 Foundations
- MA151 Algebra 1

Leads to: Most modules rely on the ideas of Linear Algebra, and it is either **assumed knowledge** or **useful background** for all future study in mathematics. In the current 2nd year, the most direct following module is the following, but note that it will change in some respects from 2023-24, when it will be replace by

- MA268 Algebra 3

though the scientific content will continue in the curriculum:

- Second Year Algebra Core

Aims: To provide a working understanding of matrices and vector spaces for later modules to build on and to teach students practical techniques and algorithms for fundamental matrix operations and solving linear equations.

Content: Many problems in maths and science are solved by reduction to a system of simultaneous linear equations in a number of variables. Even for problems which cannot be solved in this way, it is often possible to obtain an approximate solution by solving a system of simultaneous linear equations, giving the "best possible linear approximation".

The branch of maths treating simultaneous linear equations is called linear algebra. The module contains a theoretical algebraic core, whose main idea is that of a vector space and of a linear map from one vector space to another. It discusses the concepts of a basis in a vector space, the dimension of a vector space, the image and kernel of a linear map, the rank and nullity of a linear map, and the representation of a linear map by means of a matrix.

These theoretical ideas have many applications, which will be discussed in the module. These applications include:

- Solutions of simultaneous linear equations
- Properties of vectors
- Properties of matrices, such as rank, row reduction, eigenvalues and eigenvectors
- Properties of determinants and ways of calculating them

Objectives: We must understand the ideas of linearly independent vectors, spanning sets and bases of vector spaces. We must also understand the equivalence of linear maps between vector spaces and matrices and be able to row reduce a matrix, compute its rank and solve systems of linear equations. The definition of a determinant in all dimensions will be given in detail, together with applications and techniques for calculating determinants. We must know the definition of the eigenvalues and eigenvectors of a linear map or matrix, and know how to calculate them.

Books: The lecture notes will provide comprehensive coverage of the material, but it is all standard foundational mathematics and you can compare how it is covered in many other sources.

David Towers, *Guide to Linear Algebra*, Macmillan 1988.

Howard Anton, *Elementary Linear Algebra*, John Wiley and Sons, 1994.

Paul Halmos, *Linear Algebra Problem Book*, MAA, 1995.

G Strang, *Linear Algebra and its Applications*, 3rd ed, Harcourt Brace, 1988.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA151 Algebra 1

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma151/)
Lecturer: Richard Lissaman

Term(s): Term 1

Status for Mathematics students: Core

Commitment: 30 lectures, written assignments

Assessment: 15% from assignments and 85% from April exam

Formal registration prerequisites: None

Assumed knowledge: Grade A in A-level Further Maths or equivalent

Useful background: Knowledge of modular arithmetic, manipulation of polynomials (including long division), language of functions, terms 'commutative' and 'associative'

Synergies: Specifically:

- MA132 Foundations
- MA150 Algebra 2
- MA268 Algebra 3

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA150 Algebra 2
- MA268 Algebra 3
- MA263 Multilinear Algebra
- MA257 Introduction to Number Theory

This module provides an introduction to two algebraic structures which are fundamental in mathematics: groups and rings. You'll meet both of these structures many times in your study of mathematics and they have many applications in other disciplines.

Both structures are concerned with combining objects in a collection to produce new objects in that collection, so called binary operations. Addition is an example of a binary operation on the integers. It takes in two integers e.g. 2 and 5 and gives us a new integer, 7 = 2 + 5.

We'll see that groups occur very naturally in mathematics, including mathematics you'll already be very familiar with, and that they are a means to classify the 'symmetries' of an object.

You are already very familiar with some examples of rings. The integers with their regular addition and multiplication is a ring. Rings have many applications including some in coding theory and cryptography.

Aims:

To introduce groups and rings, driven by both examples and elementary theory.

Content:

Group Theory: motivating examples (numbers, cyclic group, dihedral group, symmetric group, transformations of the plane), elementary properties, subgroups, odd and even permutations.

Ring Theory: commutative and non-commutative rings, fields, examples (the integers, polynomials with integer coefficients, polynomials with real coefficients and quotient rings of such, unit groups, factorisations in the integers and polynomials.

List of covered algebraic definitions: group, subgroup, group homomorphism (including kernel, image, isomorphism), order, sign of permutation, ring, field, subring, ideal, ring homomorphism (including kernel, image, isomorphism), quotient ring

Objectives:

To explore a wide range of examples of groups and rings; to cover elementary properties of both structures; to start to look at ways to study and classify groups and rings as abstract objects. As a result of taking this module, students should be sufficiently prepared for the appearance of groups and rings in other first year courses and in follow-up second year courses.

Books:

Any book with 'Abstract Algebra' in the title is worth looking at (there are many). Here are a few specific recommendations (but note that comprehensive lecture notes will be provided):

Lara Alcock – *How to Think About Abstract Algebra*

Tony Barnard and Hugh Neill - *Discovering Group Theory*

I.N.Herstein - *Topics in Algebra*

Nathan Jacobson - *Lectures in Abstract Algebra*

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Course Regulations for Year 1 from 2021/22

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/)

To create a printable version of this section of the Handbook click on the "pages to go" link at the bottom right.

MATHEMATICS BSC. G100, MASTER OF MATHEMATICS MMATH G103, MATHEMATICS WITH BUSINESS STUDIES G1NC.

Normal Load = 120 CATS. Maximum Load = 150 CATS.

Students must take the 8 core modules (total 90 CATS), plus options. List A modules have a high mathematical content. The Core modules are: MA106 Linear Algebra, MA131 Analysis, MA132 Foundations, MA133 Differential Equations, MA134 Geometry and Motion, MA136 Introduction to Abstract Algebra, MA124 Maths by Computer, ST111 Probability A.

MATHEMATICS AND ECONOMICS GL11

The first year is in common with the BSc Mathematics degree course G100, with the addition of EC107 Economics I and ST112 Probability B as additional core modules (total core of 126 CATS).

Note. The Mathematics Department does not make first year List A modules compulsory, in order to give students (including those on joint degree courses) freedom of choice in building their options. However, the List A modules are important for many subsequent pure and applied maths modules, and we recommend that first year students take as many as possible to maintain flexibility for future maths modules. Choosing options is discussed here, and the first year List A options are discussed below.

Of the core, the modules MA131 Analysis, MA133 Differential Equations, MA106 Linear Algebra and MA134 Geometry and Motion are designated as being "required cores". This means that all first years **must** pass these modules (at 40%) either in the Summer exams or the resit exams the following September, in order to progress in to the second year, alongside getting an overall 40% for the year and passing at least 90 CATS of modules.

GL11 students must in addition pass EC107.

Additional advice to first year students

Maths Modules

Term	Code	Module	CATS	List
Pre-Term	MA1K2	Refresher Mathematics	0	Core
Term 1	MA132	Foundations	12	Core
	MA133	Differential Equations	12	Core
	MA136	Introduction to Abstract Algebra	6	Core
Term 1 & 2	MA131	Analysis I and II	24	Core
Term 2	MA106	Linear Algebra	12	Core
	MA124	Maths by Computer	6	Core
	MA134	Geometry and Motion	12	Core
	MA117	Programming for Scientists	12	List B

Maths Modules for External Students

These modules are not available to Maths students.

Term	Code	Module	CATS
Term 1	MA138	Sets and Numbers	12
Term 1 & 2	MA137	Mathematical Analysis I and II	24
Term 2	MA113	Differential Equations A	6

Statistics Modules

First year mathematics students interested in transferring to MORSE (Mathematics, Operational Research, Statistics and Economics) should include the following modules among their options

EC106 Introduction to Quantitative Economics(24 CATS, Terms 1-2);
IB104 Mathematical Programming I (12 CATS version, Term 3);
ST112 Probability B (6 CATS, Term 2)
ST104 Statisitcal Laboratory I (12 CATS, Terms 2-3)

This would allow transfer into the second year of MORSE, which consists of roughly equal proportions from the four participating departments (Statistics, Economics, Business Studies and Mathematics). Further details of MORSE can be obtained from the Statistics Department.

For transfer into Mathematics and Statistics students should take

ST112 Probability B (6 CATS, Term 2)
ST104 Statisitcal Laboratory I (12 CATS, Terms 2-3)

Transfer into any Statistics course will depend on available capacity and is likely to be restricted to only the strongest students.

Both Probability A (core) and Probability B are also essential for any further Statistics options in later years.

Term	Code	Module	CATS	List
Terms 2 and 3	ST104	ST104 Statistical Laboratory I	12	List B
Term 2	ST111	Probability A	6	Core
	ST112	Probability B	6	List A Core (GL11)

Economics Modules

Mathematics & Economics (GL11) students should refer to the Economics Undergraduate handbook and to the section on joint degree courses in this handbook.

Other mathematics students (G100 or G103, BSc or MMath) may take EC106 Introduction to Qualitative Economics as an option. [Note: Maths & Economics students do NOT take EC106.] It is designed to be suitable for Mathematics students, and a good performance in this module >55% is a prerequisite for some optional second and third year Economics modules. See the Economics Department Undergraduate handbook, which also contains details of other more specialized first year economics options. **If you wish to take second year Economics modules next year then you MUST take EC106 or EC107 this year,**

Term	Code	Module	CATS	List
Terms 1 & 2	EC106	Introduction to Quantitative Economics	24	List B (not GL11)
	EC107	Economics I	30	Core (GL11 only)

Computer Science

Mathematics students should note that *at least one 1st year programming module*, or the ability to program in a high level language, *is a prerequisite* for most Computer Science modules in Years 2 and 3. There are two roughly equivalent high level programming modules. CS118 Programming for Computer Scientists which is taken by Computer Science students, and MA117 Programming for Scientists which is available to all Mathematics students as an option. MA117 satisfies the programming prerequisite for Computer Science options.

Students considering transferring to the Discrete Mathematics G4G1 degree should take the modules Discrete Mathematics & its Applications 2 as well as MA117 Programming for Scientists.

Term	Code	Module	CATS	List
Term 2	CS137	Discrete Mathematics & its Applications 2	12	List B

Physics

Physics options for Mathematics students: Weekly problem sheets are issued for all the first year Physics modules. Any combination of Physics options may be taken. However, the Physics Department recommends the following modules and combinations, especially for students who may wish to transfer to the Maths and Physics degree at the end of the first year.

- PX101 Quantum Phenomena. This module deals from first principles with one of the major components of modern Physics. It leads on to several options in 2nd year Physics (see the second year options for details).
- PX148 Classical Mechanics and Special Relativity
- PX120 Electricity and Magnetism. These lectures treat the classical description of the behaviour of particles, waves and matter.

Term	Code	Module	CATS	List
Term 1	PX148	Classical Mechanics and Special Relativity	12	List B
Term 2	PX120	Electricity and Magnetism	12	List B
	PX144	Introduction to Astronomy	6	List B
	PX147	Introduction to Particle Physics	6	List B
Term 3	PX101	Quantum Phenomena	6	List B

Philosophy Modules

Students wishing to follow modules in Philosophy should register for these modules at the start of Term 1, using the online registration system.

In order to follow 2nd or 3rd year Philosophy honours modules students must normally first have completed a total of 30 CATS of Philosophy modules at the first year level. Those in doubt should consult the module tutor of the relevant module.

Students on the Mathematics and Philosophy joint degree take the following two modules in their first year: PH142 Central Themes in Philosophy (term 2); PH136 Logic I: Introduction to Symbolic Logic (term 2). Mathematics students are also eligible for a transfer to Mathematics and Philosophy if they take the same module combination in their first year. See the Philosophy Department's website

Term	Code	Module	CATS	List
Term 1	PH144	Mind and Reality	15	List B
	PH146	Reason, Argument and Analysis	15	List B
Term 2	PH136	Logic I: Introduction to Symbolic Logic	15	List B

Warwick Business School

See Information for all WBS modules.

Note that for any WBS module you MUST register on both the University registration system (eVision) and the WBS system (MyWBS), **with the same CATS weighting**. Failure to do this may mean that you will not be permitted to continue on the module and be removed from it.

Term	Code	Module	CATS	List
Term 3	IB104	Mathematical Programming I	12	List B

Languages

The Language Centre offers academic modules in Arabic, Chinese, French, German, Japanese, Russian and Spanish at a wide range of levels. These modules are available for exam credit as unusual options to mathematicians in all years. Pick up a leaflet listing the modules from the Language Centre, on the ground floor of the Humanities Building by the Central Library. Full descriptions are available on request. Note that you may only take one language module (as an Unusual Option) for credit in each year. Language modules are available as whole year modules, or smaller term long modules; both options are available to maths students. These modules may carry 24 (12) or 30 (15) CATS and that is the credit you get. We used to restrict maths students to 24 (12) if there was a choice, but we no longer do this.

Plan ahead! Note that 3rd and 4th year students cannot take beginners level (level 1) Language modules.

There is also an extensive and very popular programme of lifelong learning language classes provided by the centre to the local community, with discounted fees for Warwick students. Enrolment is from 9am on Wednesday of week 1. These classes do not count as credit towards your degree.

The Language Centre also offers audiovisual and computer self-access facilities, with appropriate material for individual study at various levels in Arabic, Chinese, Dutch, English, French, German, Greek, Italian, Portuguese, Russian and Spanish. (This kind of study may improve your mind, but it does not count for exam credit.)

Important note for students who pre-register for Language Centre modules

It is essential that you confirm your module pre-registration by coming to the Language Centre as soon as you can during week one of the new academic year. If you do not confirm your registration, your place on the module cannot be guaranteed. If you decide, during the summer, NOT to study a language module and to change your registration details, please have the courtesy to inform the Language Centre of the amendment.

Information on modules can be found at

http://www2.warwick.ac.uk/fac/arts/languagecentre/academic/

Engineering

Mathematics students interested in taking Engineering modules in later years should see the page for year 2 and 3 modules for any prerequisites. Details of all engineering modules can be found on the Engineering web pages.

Objectives

After completing the first year students will have

- made the transition in learning style and pace from school to university mathematics;
- been introduced to the basic concepts in university mathematics, in particular proof, rigour and calculations;
- begun the study of the foundational core;
- acquired knowledge, understanding and techniques necessary to proceed to the second year.

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

General Advice to First Year Students

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/yr1advice/)
As described in the "General" section, first-year Mathematics students get regular supervisions in groups in Terms 1 and 2, and the first 6 weeks of Term 3, in groups (normally of five) which are assigned at the start of the year. Personal tutors are available to answer questions about the course, individual modules, or anything else within reason.

Your A level background. There are many different A level syllabuses, with wide variations from one exam board to another, and from one selection of modules to another; in addition, not all schools teach the entire syllabus. Thus, some students may have missed out on some material which is needed for degree work, or may only have covered some topics skimpily and without adequate practice.

For the success of your career at Warwick, it is most important that you know these topics inside out, and are able to work with them fluently, confidently, and rapidly, even in the new and sometimes unexpected contexts of university maths. In the middle of a complicated argument, a lecturer may well simply assume that you can handle this kind of stuff easily and transparently, and lack of this ability may be a serious impediment to getting the most out of the course. Before you arrive you should have attempted the Refresher Mathematics module, MA1K2, to make sure that you are up to date and proficient in the material that you need to know. This module will appear on your registrations, but does not count for any credit towards your degree.

Tutorials. Every student has a personal tutor, with whom they will (where possible) remain throughout their degree. Tutors usually see their first-year students in groups of five once every two weeks, though students can see their tutors individually, in principle, as often as they want. The aim of the regular meetings is to find out how the students are getting on, and to provide extra help where needed. At the start of the year, your tutor can also help you to choose your optional modules.

The relationship between student and tutor is an important one. Your tutor is there to help you not only with mathematical difficulties, but also with other problems that may arise: difficulties in settling down to a steady programme of study, noisy neighbours in the Halls of Residence, how to catch up after an absence through illness, etc. etc. He or she also plays an important role after examinations at the end of each year. For example, if your marks are lower than they should be because you were unwell during your exams, they can give you advice and in teh case of mitigating circumstances provide secondary evidence for the exam board (you must always provide primary evidence from third party professionals such as doctors or counsellors). Of course, this can only happen if he or she knows you and has a good idea of your ability. See also the section on Mitigation.

First year Core and List A options

The Warwick course regulations and our options scheme is listed elsewhere, but the 8 core modules (shared by all students in the Mathematics Department) add up to 90 CATS:

Core

MA106 Linear Algebra	12 CATS
MA133 Differential Equations	12 CATS
MA124 Mathematics by Computer	6 CATS
MA134 Geometry and Motion	12 CATS
MA132 Foundations	12 CATS
MA136 Introduction to Abstract Algebra	6 CATS
MA131 Analysis	24 CATS
ST111 Probability A	6 CATS

List A

ST112 Probability B	6 CATS

We recommend students to take as many of the List A options as possible during their degrees, for the sake of flexibility with maths modules in future years. ST112 Probability B is a prerequisite for most second and third year Statistics options, and is either a prerequisite or recommended for many courses in Economics and Business Studies. Students on joint degree courses have additional core modules.

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA106 Linear Algebra

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma106/)

Lecturer: Diane Maclagan and Marco Schlichting

Term(s): Term 2

Status for Mathematics students: Core for Maths

Commitment: 30 one-hour lectures

Assessment: 15% from weekly assignments, 85% from a 2 hour examination

Formal registration prerequisites: None

Assumed knowledge: A-level Mathematics and Further Mathematics

Useful background: A-level Mathematics and Further Mathematics

Synergies: All parts of mathematics, and more generally, all parts of quantitative science, use linear algebra

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA241 Combinatorics
- MA243 Geometry
- MA251 Algebra I: Advanced Linear Algebra
- MA254 Theory of ODEs
- MA258 Mathematical Analysis III

- MA259 Multivariable Calculus
- MA3D5 Galois Theory
- MA3E1 Groups and Representations
- MA398 Matrix Analysis and Algorithms
- MA3K1 Mathematics of Machine Learning
- MA3H7 Control Theory
- MA427 Ergodic Theory
- MA4J1 Continuum Mechanics
- MA4M9 Mathematics of Neuronal Networks

Content: Many problems in maths and science are solved by reduction to a system of simultaneous linear equations in a number of variables. Even for problems which cannot be solved in this way, it is often possible to obtain an approximate solution by solving a system of simultaneous linear equations, giving the "best possible linear approximation".

The branch of maths treating simultaneous linear equations is called linear algebra. The module contains a theoretical algebraic core, whose main idea is that of a vector space and of a linear map from one vector space to another. It discusses the concepts of a basis in a vector space, the dimension of a vector space, the image and kernel of a linear map, the rank and nullity of a linear map, and the representation of a linear map by means of a matrix.

These theoretical ideas have many applications, which will be discussed in the module. These applications include:

- Solutions of simultaneous linear equations
- Properties of vectors
- Properties of matrices, such as rank, row reduction, eigenvalues and eigenvectors
- Properties of determinants and ways of calculating them

Aims: To provide a working understanding of matrices and vector spaces for later modules to build on and to teach students practical techniques and algorithms for fundamental matrix operations and solving linear equations.

Objectives: Students must understand the ideas of linearly independent vectors, spanning sets and bases of vector spaces. They must also understand the equivalence of linear maps between vector spaces and matrices and be able to row reduce a matrix, compute its rank and solve systems of linear equations. The definition of a determinant in all dimensions will be given in detail, together with applications and techniques for calculating determinants. Students must know the definition of the eigenvalues and eigenvectors of a linear map or matrix, and know how to calculate them.

Books:

David Towers, *Guide to Linear Algebra*, Macmillan 1988.

Howard Anton, *Elementary Linear Algebra*, John Wiley and Sons, 1994.

Paul Halmos, *Linear Algebra Problem Book*, MAA, 1995.

G Strang, *Linear Algebra and its Applications*, 3rd ed, Harcourt Brace, 1988.

Recommended Syllabus

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA112 Experimental Maths

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma112/)
Lecturers: Andrew Brendon-Penn and Mark Cummings

Term(s): Not running 2020/21

Status for Mathematics students: List A for Maths

Commitment: One 3 hour lab session per week for 4 weeks (during weeks 1-5 of term 3)

Assessment: 100% by written reports on each of the projects

Prerequisites: Most core 1st year mathematics modules, especially MA133 Differential Equations, MA131 Analysis, MA136 Abstract Algebra, MA124 Maths by Computer, and MA134 Geometry & Motion.

Leads To: MA259 Multivariable Calculus, MA209 Variational Principles, MA250 Partial Differential Equations, MA3J3 Bifurcation, Catastrophes and Symmetry

Content:
This module consists of a series of 4 laboratory projects which combine physical or computer experiments with mathematical modelling and analysis. The projects will include work on symmetry breaking, catastrophe theory, nonlinear oscillators, period doubling, and coupled pendula.

Much more information is provided on the Additional Resources page, linked below. Due to deregistration dates being before the start of the module, we strongly advise all students who are seriously considering taking the module to read this.

Aims:
To demonstrate that mathematical ideas and techniques can be used to predict and explain `real life' phenomena and that, conversely, physical intuition can lead to mathematical insights.

Objectives:

1. To show how various aspects of mathematics seen in earlier modules can be applied to real-world situations, such as the application of differential equations to the study of coupled and nonlinear oscillators.
2. To illustrate the use of simple group theoretical ideas in problems with symmetries.
3. To provide an opportunity for students to learn the thought process used to solve long and complicated problems, by breaking them down into smaller, more manageable pieces.
4. To provide an opportunity for students to develop report writing skills.
5. To provide an opportunity for students to develop the ability to work in groups.

Books:
As this module follows on from several core first year modules, you are recommended to check the recommended texts for those modules.

Additional Resources

Archived Pages: 2012 2014 2015

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA117 Programming for Scientists

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma117/)
Lecturer: Andrew Hague (DCS)

Term(s): Term 2

Status for Mathematics students: List B for Maths

Commitment: 10 lectures plus lab sessions/tutorials

Assessment: Three programming assignments.

Prerequisites: No previous computing experience will be assumed, but students should have obtained a code to use the IT Services work area systems prior to this module. Information and assistance is available in the Student Computer Centre in the Library Road.

Leads to:

- MA4M1 Epidemiology by Example

Content: Aspects of software specification, design, implementation and testing will be introduced in the context of the Java language. The description of basic elements of Java will include data types, expressions, assignment and compound, alternative and repetitive statements. Program structuring and object oriented development will be introduced and illustrated in terms of Java's method, class and interface. This will enable the development of software that reads data in a variety of contexts, performs computations on that data and displays results in text and graphical form. Examples of iterative and recursive algorithms will be given. The importance of Java and Java Virtual Machine in networked computing will be described. The majority of examples will be standard applications but the development of Java Applets to be delivered by web browsers will also be covered.

Aims: To provide an understanding of the process of scientific software development and an appreciation of the importance of data vetting, sound algorithms and informative presentation of results.

Objectives: To enable the student to become confident in the use of the Java language for scientific programming.

Books:

Books are not essential for this module as use will be made of on-line tutorial and reference material. An informative, optional text is

H M Deitel & P J Deitel, *Java How to Program* (2nd or 3rd Ed), Prentice Hall.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA124 Mathematics by Computer

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma124/)
Lecturer: Richard Lissaman and Marya Bazzi

Term(s): Term 1 and 2

Status for Mathematics students: Core for Maths

Commitment: One lecture per week with one 1-hour help class per week

Assessment: The material learnt in the contact sessions will be assessed through five assignments, counting for 100% of the total mark

Formal registration prerequisites: None

Assumed knowledge: None, other than that already covered in core first-year mathematics modules

Useful background: Prior experience with Python or other programming languages will be useful

Synergies: The assignments will make contact with material from other first-year mathematics modules, in particular:

- MA133 Differential Equations
- MA131 Analysis
- MA106 Linear Algebra
- MA134 Geometry and Motion

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA261 Differential Equations: Modelling and Numerics
- MA398 Matrix Analysis and Algorithms
- MA4M1 Epidemiology by Example

By the end of the module you will find the computer to be a tool that can aid you throughout your life as a mathematician and, in particular, in many modules you will take at Warwick. Specific modules which might use Matlab include: MA261 Differential Equations: Modelling and Numerics, MA398 Matrix Analysis and Algorithms, MA3H7 Control Theory. But you should think of your computing skills as a powerful resource to be used, potentially, at any time.

Aims:

The first aim is to show how the computer may be used, throughout all of mathematics, to enhance understanding, make predictions and test ideas.

Objectives:

The module will be taught using Python. Through using this language you will be introduced to the rudiments of computer programming.

You will learn how to graph functions, study vectors and matrices graphically and numerically, how to iterate and use iteration to study sequences and series, how to solve algebraic and differential equations numerically, how to use symbolic algebra in Python as well as some statistical techniques.

Books:

- M Lutz, *Learning Python*, O'Reilly Media Inc., 3rd edition, 2007, ebook here
- JV Guttag, *Introduction to Computation and Programming Using Python*, MIT Press, 2nd edition, 2016, ebook here

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA125 Introduction to Geometry

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma125/)
Lecturer: Meritxell Saez

Term(s): Not running 2021/22

Status for Mathematics students: List A for Maths

Commitment: Fifteen one-hour lectures

Assessment: One-hour exam taken in the summer term

Prerequisites:

Leads To: MA243 Geometry

Content: This module begins with a quick tour through elementary plane Euclidean geometry. We emphasise proof, and the careful use of diagrams as an aid to understanding problems and finding proofs. Plane geometry then provides the setting for an introduction to the geometry of the sphere and of polyhedra.

Aims:

- To learn and enjoy Euclidean geometry of the plane, the sphere and of three-dimensional space.
- To learn to visualise geometrical problems, and to draw diagrams which represent them accurately.
- To learn to reason from diagrams, and use them as an aid to writing rigorous proofs.
- To learn to construct proofs, and to set them out clearly and convincingly.

Objectives: You will gain familiarity with

- Plane Euclidean geometry: isometries, congruence and similarity; theorems on triangles, circles, tangents and angles; ruler and compass constructions.
- Polyhedra: the Euler characteristic; classification and construction of regular polyhedra.
- Spherical geometry: the angle-sum formula for spherical triangles; stereographic projection and its relation with inversion; conformal (angle-preserving) maps.

Books:

Notes for the module will be available at cost price from the departmental office.

Also relevant: G.A. Jennings, *Modern geometry with applications*, Springer-Verlag (a fine book with many challenging exercises, but useful only as a complement to the course).

Additional Resources

Archived Pages Pre-2011 2012 2016 2017

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA131 Analysis I and II

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma131/)
Lecturer:
Term 1: Daniel Ueltschi

Term 2: Keith Ball

Term(s): Terms 1 & 2

Status for Mathematics students: Core for Maths

CAUTION: This entry refers to arrangements for students based in the Mathematics Department (those who entered through the Mathematics Department and have a Personal Tutor there). All other students should be registered on MA137 Mathematical Analysis.

Commitment: One lecture per week, two 1-hour classes per week

Assessment: Weekly assignments (15%), January exam (25%), June exam (60%)

Formal registration prerequisites: None

Assumed knowledge: None

Useful background: None

Synergies: Analysis is one of the two most fundamental parts of pure mathematics with the other being algebra. This module forms the foundation on which many other modules will be built. Amongst the first year modules, the ones most closely related are: MA133 Differential Equations and MA134 Geometry and Motion. Analysis also has close connections to applied mathematics, probability theory and physics.

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA222 Metric Spaces
- MA260 Norms, Metrics and Topologies
- MA254 Theory of ODEs
- MA259 Multivariable Calculus
- MA4J1 Continuum Mechanics

Content: At the beginning of the nineteenth century, the familiar tools of calculus, differentiation and integration, began to run into problems. Mathematicians were unsure of how to apply these tools to sums of infinitely many functions. The origins of Analysis lie in their attempt to formalize the ideas of calculus purely in the the language of arithmetic and to resolve these problems.

You will study ideas of the mathematicians: Cauchy, Dirichlet, Weierstrass, Bolzano, D'Alembert, Riemann and others, concerning sequences and series in term one, continuity and differentiability in term two and integration in term one of your second year.

By the end of the year you will be able to answer many interesting questions: What do we mean by `infinity'? How can you accurately compute the value of π or e or $\sqrt{2}$? How can you add up infinitely many numbers, or infinitely many functions? Can all functions be approximated by polynomials?

There will be considerable emphasis throughout the module on the need to argue with much greater precision and care than you had to at school. With the support of your fellow students, lecturers and other helpers, you will be encouraged to move on from the situation where the teacher shows you how to solve each kind of problem, to the point where you can develop your own methods for solving problems. You will also be expected to question the concepts underlying your solutions, and understand why a particular method is meaningful and another not so. In other words, your mathematical focus should shift from problem solving methods to concepts and clarity of thought.

Books:
M. Hart, *Guide to Analysis*, Macmillan. (A good traditional text with theory and many exercises.)
K.G. Binmore, *Mathematical Analysis: A Straightforward Approach*, CUP (1982)

R.G Bartle and D.R Sherbert, *Introduction to Real Analysis*, (4th Edition), Wiley (2011)

L. Alcock, *How To Think About Analysis*, Oxford University Press (2014)

Recommended Syllabus

Additional Resources Analysis I (Term 1)

Additional Resources Analysis II (Term 2)

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA132 Foundations

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma132/)
Lecturer: Dave Wood

Term(s): Term 1

Status for Mathematics students: Core

Commitment: 30 lectures, 10 weekly assignments with 4 or 5 fortnightly tests based on them

Assessment: 15% from fortnightly tests and 85% from January exam

Formal registration prerequisites: None

Assumed knowledge: Grade A in A-level Maths or equivalent.

Useful background: Some elementary knowledge of modular arithmetic, induction principle, set notation.

Synergies: Most later pure mathematics modules specifically:

- MA136 Introduction to Abstract Algebra
- MA131 Analysis
- MA106 Linear Algebra
- MA251 Algebra I: Advanced Linear Algebra

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA222 Metric Spaces
- MA260 Norms, Metrics and Topologies
- MA257 Introduction to Number Theory
- MA249 Algebra II: Groups and Rings
- MA3E1 Groups and Representations
- MA3A6 Algebraic Number Theory
- MA3D5 Galois Theory
- MA3H3 Set Theory

Aims: University mathematics introduces progressively more and more abstract ideas and structures, and demands more and more in the way of proof, until by the end of a mathematics degree most of the student's time is occupied with understanding proofs and creating his or her own. This is not because university mathematicians are more pedantic than schoolteachers, but because proof is how one knows things in mathematics, and it is in its proofs that the strength and richness of mathematics is to be found.

Learning to deal with abstraction and with proofs takes time. This module aims to bridge the gap between school and university mathematics, by beginning with some rather concrete techniques where the emphasis is on calculation, and gradually moving towards abstraction and proof.

Indicative Content:

- **Naive Set Theory, Counting and Lists:**
  Sets and functions, injections, surjections and bijections, permutations.
  Lists, sublists, lists as functions, strings.
  Subsets, power sets, partition, infinite versus finite, Cantor's Theorem.
- **Operations on Sets, Lists, Functions:**
  Ordered pairs, cartesian products, functions and graphs, functions and lookup tables.
  Union, intersection, set difference, list concatenation.
  Composition, iteration, orbits, Cantor-Schroeder-Bernstein, cardinalities.
- **Relations:**
  Reflexive, symmetric, transitive.
  Orders, equivalence classes and relations: integers, rational numbers, partitions.
  Kernels and co-kernels, well-definedness, modular arithmetic.
- **Logic:**
  Variables, booleans, negation, operations.
  Operators and formulas via truth tables.
  Quantifiers, tautologies, deduction rules.
- **Proof:**
  What is proof? False proofs, examples, subtle issues (diagrams, hand-waving)
  Kinds of proof: direct, contraposition, contradiction, construction, cases.
  Recursion, induction, pigeonhole principle, counting.
- **Algorithms in Algebra and Cryptography:**
  What is algorithm? Euclid's algorithm, operational complexity, P=NP
  Discrete Logarithm, introduction to cryptography, Diffie-Hellman key exchange.
  Prime factorisation, primality testing, Chinese Remainder Theorem
  RSA (Rivest–Shamir–Adleman) public key exchange

Objectives: Students will work with number systems and develop fluency with their properties; they will learn the language of sets and quantifiers, of functions and relations and will become familiar with various methods and styles of proof.

Books:
None of these is the course text, but each would be useful, especially the first:
A.F.Beardon, *Algebra and Geometry*, CUP, 2005.
I.N. Stewart and D.O. Tall, *Foundations of Mathematics*, OUP, 1977.
J. A. Green, *Sets and Groups; First Course in Algebra*, Chapman and Hall, 1995.

Recommended Syllabus

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA133 Differential Equations

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma133/)
Lecturer: Dwight Barkley

Term: Term 2

Status for Mathematics students: Core

Commitment: 30 lectures

Assessment: 15% from fortnightly assignments, 85% from a 2 hour examination

Formal registration prerequisites: None

Assumed knowledge: A-level mathematics or equivalent, in particular Calculus topics from Pure

Useful background: Proficiency with Mechanics from Maths A-level, or having taken Physics A-level, useful but not essential, we will cover necessary topics from first principles

Synergies: This module leads on to any module using differential or partial differential equations, most immediately MA134 Geometry and Motion in Term 2

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA254 Theory of ODEs
- MA261 Differential Equations: Modelling and Numerics
- MA250 Introduction to Partial Differential Equations
- MA269 Asymptotics and Integral Transforms
- MA256 Introduction to Mathematical Biology
- MA258 Mathematical Analysis III
- MA209 Variational Principles
- MA390 Topics in Mathematical Biology
- MA3J3 Bifurcations, Catastrophes and Symmetry
- MA3H7 Control Theory

- MA4J1 Continuum Mechanics
- MA4M9 Mathematics of Neuronal Networks

Content: How do you reconstruct a curve given its slope at every point? Can you predict the trajectory of a tennis ball? The basic theory of ordinary differential equations (ODEs) as covered in this module is the cornerstone of all applied mathematics. Indeed, modern applied mathematics essentially began when Newton developed the calculus in order to solve (and to state precisely) the differential equations that followed from his laws of motion.

However, this theory is not only of interest to the applied mathematician: ideas from the theory of ODEs prove invaluable in various branches of pure mathematics, such as geometry and topology. The first half of this module will focus on ordinary differential equations - how to understand them and how to solve them. The second half of the module covers topics from multivariable calculus - partial derivatives, div, grad, curl, and some differential geometry and integration needed for subsequent modules on differential equations.

Aims: To introduce simple differential equations and methods for their solution and to provide a solid foundation in the calculus needed to study future modules involving ordinary and partial differential equations.

Objectives: You should be able to solve various simple differential equations (first order, linear second order and coupled systems of first order equations), be able to manipulate div, grad, and curl operations, and be able to integrate over simple curves and surfaces.

Books:

The primary text will be:
J. C. Robinson *An Introduction to Ordinary Differential Equations*, Cambridge University Press 2003.
J. Stewart, D. Clegg, S. Watson, *Multivariable Calculus, ninth edition, metric version*, Brooks/Cole 2022.

Additional references are:
W. Boyce and R. Di Prima, *Elementary Differential Equations and Boundary Value Problems*, Wiley 1997.

Recommended Syllabus

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA134 Geometry and Motion

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma134/)
Lecturer: Siri Chongchitnan and Thomas Hudson

Term(s): Term 2

Status for Mathematics students: Core for Maths

Commitment: 30 lectures

Assessment: 85% Examination, 15% Assessment

Formal registration prerequisites: None

Assumed knowledge: Vector identities involving dot and cross products, equations of circles, ellipses and hyperbolae in $\mathbb{R}^2$, polar coordinates and sketching polar curves, equations of lines and planes in $\mathbb{R}^3$, differentiation and integration techniques, Taylor expansion.

Useful background: Parametric curves in $\mathbb{R}^2$, Cartesian equations of simple surfaces (e.g. a sphere), plotting curves and surfaces in $\mathbb{R}^2$ and $\mathbb{R}^3$ online (e.g. math3d.org) or using Python

Synergies: MA133 Differential Equations and all Term 2 MA modules

Leads To: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA254 Theory of ODEs
- MA243 Geometry
- MA250 Introduction to Partial Differential Equations
- MA259 Multivariable Calculus
- MA269 Asymptotics and Integral Transforms
- MA4J1 Continuum Mechanics

This module leads on directly to MA259 Multivariable Calculus and, together with MA133 Differential Equations, provides the foundations for most future applied mathematics modules including MA250 Partial Differential Equations, MA209 Variational Principles. The geometric aspects of the module also lead on to MA3D9 Geometry of Curves and Surfaces. The proper theory of integration of functions of several variables is done in MA359 Measure Theory.

Content: When a particle moves in space, it traces out a curve as a function of time. This parametric description of a curve gives us an important connection between geometry and motion.

We will study parametric curves using the tools of *vector calculus*. We will also see how surfaces can be described parametrically using 2 parameters. The properties of curves, surfaces and volumes will be studied using partial differentiation and multiple integrals.

Aims: This module aims to indicate to students how intuitive geometric and physical concepts such as length, area, volume, curvature, mass, circulation and flux can be translated into mathematical formulas. It also aims to teach the practical calculation of these formulas and their application to elementary problems in particle/fluid mechanics.

Objectives: On successful completion of this module students should be able to:

- Parametrise simple curves and surfaces in cartesian and other coordinates, including polar, cylindrical and spherical coordinates
- Calculate lengths and curvatures of curves in R^3 and demonstrate that length is independent of parametrisation
- Understand and be able to calculate line, surface and volume integrals with respect to various coordinate systems. This includes change of variables and change of order of integration in repeated integrals
- Understand and prove simple properties of a conservative vector field
- State the Divergence and Stokes' Theorems and use them to aid calculations
- Apply all these techniques to problems in mechanics (mass, work, circulation and flux) and geometry (area, volume, centre of mass).

Books:

See the reading list on Talis.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA136 Introduction to Abstract Algebra

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ma136/)
Lecturer: Richard Lissaman

Term(s): Term 1

Status for Mathematics students: Core for Maths

Commitment: 15 one hour lectures

Assessment: Assignments (15%), Written exam (85%)

Formal registration prerequisites: None

Assumed knowledge: A-level Mathematics and Further Mathematics

Useful background: Some elementary knowledge of matrices, functions, modular arithmetic

Synergies:

- MA106 Linear Algebra
- MA132 Foundations or MA138 Sets and Numbers

Leads To: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA249 Algebra II
- MA251 Algebra I: Advanced Linear Algebra
- MA257 Introduction to Number Theory
- MA3F1 Introduction to Topology
- MA3E1 Groups and Representations
- MA4H4 Geometric Group Theory

Content:

Section 1 Group Theory:

- Motivating examples: numbers, symmetry groups
- Definitions, elementary properties
- Subgroups, including subgroups of Z
- Arithmetic modulo n and the group Z_n
- Lagrange's Theorem
- Permutation groups, odd and even permutations (proof optional)
- Normal subgroups and quotient groups

Section 2 Ring Theory:

- Definitions: Commutative and non-commutative rings, integral domains, fields
- Examples: Z, Q, R, C, Z_n, matrices, polynomials, Gaussian integers

Aims:

To introduce First Year Mathematics students to abstract Algebra, covering Group Theory and Ring Theory.

Objectives:

By the end of the module students should be able to understand:

- the abstract definition of a group, and be familiar with the basic types of examples, including numbers, symmetry groups and groups of permutations and matrices.
- what subgroups are, and be familiar with the proof of Lagrange's Theorem.
- the definition of various types of ring, and be familiar with a number of examples, including numbers, polynomials, and matrices.
- unit groups of rings, and be able to calculate the unit groups of the integers modulo n.

Books:

Any library book with Abstract Algebra in the title would be useful.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

ST114 Games and Decisions

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/st114/)
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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

EC106 Introduction to Quantitative Economics

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ec106/)

  

259 total students

40 total lecture hours

40 total contact hours

30 CATS - Department of Economics

Principal Aims

This module provides students who have a mathematical background with an introduction to both microeconomics and macroeconomics. It is taught using a non-mathematical approach, with the focus on providing an intuitive understanding to core economic theory, which will also include 'real world' applications. Graphical analysis will also be used to illustrate key concepts, giving students a different way of examining problems that will complement the mathematics skills learnt in other modules.

Play

00:00 / 02:05

Principal Learning Outcomes

Demonstrate knowledge of economic behaviours, outcomes, trends, developments, phenomena, institutions and policies

Demonstrate the capacity for abstract reasoning and to simplify economic problems through the application of theoretical models

Demonstrate an understanding of key concepts, principles, theories and models in Economics

Demonstrate the capacity to interpret economic data and to use data to inform the selection and application of appropriate economic tools of analysis

Demonstrate the capacity to comment and facilitate in formulating economic policy

Syllabus

Term 1: microeconomics, which is concerned with the economic behaviour of individual consumers and producing firms, and their interaction in markets for goods, services and factors of production, strategic interaction and the analysis of externalities and public goods. The module will typically consider some of the following topics:

What is Economics; Demand and Supply; Consumer Choice; Uncertainty; Information; Production; Costs; The Market Mechanism; Perfect Competition; Imperfect Competition, including Monopoly, Monopolistic Competition and Oligopoly; Game Theory; Market Failure, including Externalities and Public Goods

Term 2: macroeconomics, which is concerned with aggregate economic variables or the workings of the national economy as a whole: aggregate output (Gross Domestic Product or GDP), employment and unemployment, inflation, interest rates, the balance of payments, exchange rates, etc., and with government economic policies to influence these variables.

Introduction to Macroeconomics; Economic Growth; National Accounts, Alternative Measurements; The Distribution of Income; Aggregate Demand and Aggregate Supply; Equilibrium National Income; Inflation; Unemployment; The Phillips Curve; The Money Market; Interest Rates; The Financial System; ISLM analysis; The Great Depression; Economic and Financial Crises; The 3-Equation Model; Macroeconomic Policy; Technological Change; Models of Capital Accumulation; The Open Economy

Context

Core Module	G300 - Year 1, Y602 - Year 1
Optional Module	G100 - Year 1, G103 - Year 1
Pre or Co-requisites	A-level Mathematics or the equivalent

Assessment

Assessment Method	Coursework (20%) + Online Examination (80%)
Coursework Details	Online Examination (80%), Test 1 (10%), Test 2 (10%)
Exam Timing	Summer

Reading Lists

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

EC107 Economics 1

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/ec107/)

330 total students

40 total lecture hours

16 total seminars

56 total contact hours

30 CATS - Department of Economics

Principal Aims

This module allows students to develop an understanding of fundamental and intermediate concepts in micro and macroeconomic analysis by equipping them with a range of appropriate analytical skills, including descriptive, graphical and mathematical methods. This allows students to develop the capacity to apply analytical techniques to real world problems.

Play

00:00 / 02:11

Principal Learning Outcomes

Subject Knowledge and Understanding:... demonstrate knowledge of economic behaviours, outcomes, trends, developments, phenomena, institutions and policies.

Subject Knowledge and Understanding:...demonstrate an understanding of key concepts, principles, theories and models in Economics.

Subject Specific/Professional Skills:...demonstrate the capacity for abstract reasoning and to simplify economic problems through the application of theoretical models.

Subject Specific/Professional Skills:...demonstrate the capacity to interpret economic data and to use data to inform the selection and application of appropriate economic tools of analysis.

Syllabus

Typically, topics covered will include those such as:

Micro (term 1)

• The Capitalist Revolution

• Technology, Population and Growth

• Scarcity, Work and Choice

• Social Interactions

• Property and Power

• The Firm: Owners, managers and employees

• The Firm and its Customers

• Supply and Demand

• Markets, Efficiency and Public Policy

Macro (Term 2)

• Consumption, saving and investment.

• Aggregate demand, the multiplier and the IS curve

• The labour discipline model of equilibrium unemployment

• Wage setting, inflation and the Phillips Curve

• Social Preferences over inflation and unemployment, the central bank

• Monetary policy stabilisation: central bank responses to economic shocks

- Fiscal policy stabilisation
- Economic growth in historical and global perspective
- The Solow model of economic growth

Context

Core Module	LM1D (LLD2) - Year 1, V7ML - Year 1, GL11 - Year 1, GL12 - Year 1, L1L8 - Year 1, R9L1 - Year 1, R3L4 - Year 1, R4L1 - Year 1, R1L4 - Year 1, R2L4 - Year 1
Pre or Co-requisites	This module is available as an optional module for all students outside the Economics Department (except for WBS students) who have achieved a Grade B or better in Mathematics at A-level, or the equivalent. It is a pre-requisite for EC204: Economics 2 and EC238/EC239.

Assessment

Assessment Method	Coursework (30%) + Online Examination (70%)
Coursework Details	Assessment 1: Problem set (group work) Micro (5%), Assessment 2: MCQ Test (10%), Assessment 3: Problem set (group work) Macro (5%), Assessment 4: MCQ Test (10%), Online Examination (70%)
Exam Timing	Summer

Exam Rubric

Time Allowed: 3 Hours

Read all instructions carefully- and read through the entire paper at least once before you start entering your answers.

There are THREE Sections in this paper. Answer ALL questions in Section A (40 marks total). Answer TWO questions in Section B (30 marks total); and TWO questions in Section C (30 marks total).

Approved pocket calculators are allowed.

You should not submit answers to more than the required number of questions. If you do, we will mark the questions in the order that they appear, up to the required number of questions in each section.

Previous exam papers can be found in the University's past papers archive. Please note that previous exam papers may not have operated under the same exam rubric or assessment weightings as those for the current academic year. The content of past papers may also be different.

Reading Lists

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

CS126 Design of Information Structures

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/cs126/)

CS126-15 Design of Information Structures

Academic year	**22/23**
Department	**Computer Science**
Level	**Undergraduate Level 1**
Module leader	**Charilaos Efthymiou**
Credit value	**15**
Module duration	**10 weeks**

Assessment	**Multiple**
Study location	**University of Warwick main campus, Coventry**

Download as PDF

Description	Study	Assessment	Availability

Introductory description

CS126 is all about data structures and how to program them.

We are interested in: what common data structures exist; how we can program those data structures; how we can represent them efficiently; how we can reason about them (in a formal manner).
We are also interested in common algorithms that use data structures, including: searching for data; sorting data.

Module aims

The module aims for students to:

- gain familiarity with the specification, implementation and use of some standard abstract data types (ADTs) such as linked-lists, stacks, queues, graphs etc.
- learn some standard algorithms for common tasks (such as searching and sorting) and some elementary methods of measuring the complexity, and of showing the correctness, of algorithms;
- learn how to program with non-standard ADTs using an object-oriented language.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

- Types and their properties: simple types in programming languages; relationship between familiar mathematical and program objects of given type. Using predicate logic to state properties of types and their operations in terms of pre- and post-conditions.
- Abstract data types: specification of familiar abstract objects (eg complex numbers, sets, sequences, matrices) and their operations, comparison with their implementation using a typical programming language. Specification and implementation of some important standard types (eg strings, stacks and queues).
- Algorithms: relationship between data structures and algorithms; some standard algorithms for searching, sorting and pattern matching. Elementary analysis of complexity. Reasoning about the correctness of the implementation of simple algorithms.

Learning outcomes

By the end of the module, students should be able to:

- After completing CS126 Design of Information Structures, a student should be familiar with a range of standard ADTs and how they can be used to accomplish common programming tasks.
- After completing CS126 Design of Information Structures, a student should be able to assess the complexity and correctness of simple algorithms, and choose appropriate algorithms for simple tasks.
- After completing CS126 Design of Information Structures, a student should have practical experience of designing user-defined ADTs, and associated algorithms, for a non-standard application.

Indicative reading list

Please see Talis Aspire link for most up to date list.

View reading list on Talis Aspire

Subject specific skills

- Specifying abstract data types and implementing them in an object-oriented programming language
- Estimating the asymptotic running time of simple algorithms
- Using basic data structures to implement efficient algorithms

Transferable skills

- Creative problem solving

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

CS137 Discrete Mathematics and its Applications 2

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/cs137/)

CS147-10 Discrete Mathematics and Its Applications 2

Academic year	**22/23**
Department	**Computer Science**
Level	**Undergraduate Level 1**
Module leader	**Ramanujan Maadapuzhi Sridharan**
Credit value	**10**
Module duration	**10 weeks**
Assessment	**Multiple**
Study location	**University of Warwick main campus, Coventry**

Download as PDF

Description | Study | Assessment | Availability

Introductory description

This module is designed to introduce students to language and methods of the area of Discrete Mathematics.

Module aims

The focus of the module is on basic mathematical concepts in discrete maths and on applications of discrete mathematics in algorithms and data structures. One of the aims will be to show students how discrete mathematics can be used in modem computer science (with the focus on algorithmic applications).

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Big-Oh notation and its use in the analysis of algorithms.
Basic concepts from graph theory; such as trees, matchings, euler tours, colorings and cuts.
Applications of discrete probability; such as probabilistic method, random walks and entropy.

Learning outcomes

By the end of the module, students should be able to:

- Understand the notion of mathematical thinking, mathematical proofs, and algorithmic thinking, and be able to apply them in problem solving.
- Understand asymptotic notation, its significance, and be able to use it to analyse the runtimes of algorithms.
- Understand some basic properties of graphs and discrete probability, and be able to apply the methods from these subjects in problem solving.

Indicative reading list

To be finalised.

Subject specific skills

Basic knowledge of graph theory and its applications in algorithms
Basic knowledge of discrete probability and its applications in algorithms
Understanding and using asymptotic notations in design and analysis of algorithms

Transferable skills

Communication - Reading and writing mathematical proofs
Critical thinking - problem solving

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

PX101 Quantum Phenomena

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/px101/)
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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

PX120 Electricity & Magnetism

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/px120/)
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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information

Core module averages

PX121 Thermal Physics I

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/px121/)

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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

PX144 Introduction to Astronomy

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/px144/)

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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

PX147 Introduction to Particle Physics

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/px147/)

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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules

G103

Exam information
Core module averages

PX148 Classical Mechanics & Relativity

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/year1old/px148/)
uk.ac.warwick.sbr.content.ContentDeniedException: Access denied for the source page.

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

General Advice to First Year Students

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/yr1advice/)
As described in the "General" section, first-year Mathematics students get regular supervisions in groups in Terms 1 and 2, and the first 6 weeks of Term 3, in groups (normally of five) which are assigned at the start of the year. Personal tutors are available to answer questions about the course, individual modules, or anything else within reason.

Your A level background. There are many different A level syllabuses, with wide variations from one exam board to another, and from one selection of modules to another; in addition, not all schools teach the entire syllabus. Thus, some students may have missed out on some material which is needed for degree work, or may only have covered some topics skimpily and without adequate practice.

For the success of your career at Warwick, it is most important that you know these topics inside out, and are able to work with them fluently, confidently, and rapidly, even in the new and sometimes unexpected contexts of university maths. In the middle of a complicated argument, a lecturer may well simply assume that you can handle this kind of stuff easily and transparently, and lack of this ability may be a serious impediment to getting the most out of the course. Before you arrive you should have attempted the Refresher Mathematics module, MA1K2, to make sure that you are up to date and proficient in the material that you need to know. This module will appear on your registrations, but does not count for any credit towards your degree.

Tutorials. Every student has a personal tutor, with whom they will (where possible) remain throughout their degree. Tutors usually see their first-year students in groups of five once every two weeks, though students can see their tutors individually, in principle, as often as they want. The aim of the regular meetings is to find out how the students are getting on, and to provide extra help where needed. At the start of the year, your tutor can also help you to choose your optional modules.

The relationship between student and tutor is an important one. Your tutor is there to help you not only with mathematical difficulties, but also with other problems that may arise: difficulties in settling down to a steady programme of study, noisy neighbours in the Halls of Residence, how to catch up after an absence through illness, etc. etc. He or she also plays an important role after examinations at the end of each year. For example, if your marks are lower than they should be because you were unwell during your exams, they can give you advice and in teh case of mitigating circumstances provide secondary evidence for the exam board (you must always provide primary evidence from third party professionals such as doctors or counsellors). Of course, this can only happen if he or she knows you and has a good idea of your ability. See also the section on Mitigation.

First year Core modules

The Warwick course regulations and our options scheme is listed elsewhere, but the 9 core modules (shared by all students in the Mathematics Department) add up to 100 CATS:

Core

MA141 Analysis 1	10 CATS
MA139 Analysis 2	15 CATS
MA151 Algebra 1	10 CATS

MA150 Algebra 2	15 CATS
MA132 Foundations	10 CATS
MA146 Methods of Mathematical Modelling 1	10 CATS
MA144 Methods of Mathematical Modelling 1	10 CATS
ST120 Introduction to Probability	10 CATS
MA124 Mathematics by Computer	10 CATS

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA106 Linear Algebra

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma106/)
Lecturer: Diane Maclagan and Marco Schlichting

Term(s): Term 2

Status for Mathematics students: Core for Maths

Commitment: 30 one-hour lectures

Assessment: 15% from weekly assignments, 85% from a 2 hour examination

Formal registration prerequisites: None

Assumed knowledge: A-level Mathematics and Further Mathematics

Useful background: A-level Mathematics and Further Mathematics

Synergies: All parts of mathematics, and more generally, all parts of quantitative science, use linear algebra

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA241 Combinatorics
- MA243 Geometry
- MA251 Algebra I: Advanced Linear Algebra
- MA254 Theory of ODEs
- MA258 Mathematical Analysis III
- MA259 Multivariable Calculus
- MA3D5 Galois Theory
- MA3E1 Groups and Representations
- MA398 Matrix Analysis and Algorithms
- MA3K1 Mathematics of Machine Learning
- MA3H7 Control Theory
- MA427 Ergodic Theory
- MA4J1 Continuum Mechanics

Content: Many problems in maths and science are solved by reduction to a system of simultaneous linear equations in a number of variables. Even for problems which cannot be solved in this way, it is often possible to obtain an approximate solution by solving a system of simultaneous linear equations, giving the "best possible linear approximation".

The branch of maths treating simultaneous linear equations is called linear algebra. The module contains a theoretical algebraic core, whose main idea is that of a vector space and of a linear map from one vector space to another. It discusses the concepts of a basis in a vector space, the dimension of a vector space, the image and kernel of a linear map, the rank and nullity of a linear map, and the representation of a linear map by means of a matrix.

These theoretical ideas have many applications, which will be discussed in the module. These applications include:

- Solutions of simultaneous linear equations
- Properties of vectors
- Properties of matrices, such as rank, row reduction, eigenvalues and eigenvectors
- Properties of determinants and ways of calculating them

Aims: To provide a working understanding of matrices and vector spaces for later modules to build on and to teach students practical techniques and algorithms for fundamental matrix operations and solving linear equations.

Objectives: Students must understand the ideas of linearly independent vectors, spanning sets and bases of vector spaces. They must also understand the equivalence of linear maps between vector spaces and matrices and be able to row reduce a matrix, compute its rank and solve systems of linear equations. The definition of a determinant in all dimensions will be given in detail, together with applications and techniques for calculating determinants. Students must know the definition of the eigenvalues and eigenvectors of a linear map or matrix, and know how to calculate them.

Books:

David Towers, *Guide to Linear Algebra*, Macmillan 1988.

Howard Anton, *Elementary Linear Algebra*, John Wiley and Sons, 1994.

Paul Halmos, *Linear Algebra Problem Book*, MAA, 1995.

G Strang, *Linear Algebra and its Applications*, 3rd ed, Harcourt Brace, 1988.

Recommended Syllabus

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA112 Experimental Maths

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma112/)
Lecturers: Andrew Brendon-Penn and Mark Cummings

Term(s): Not running 2020/21

Status for Mathematics students: List A for Maths

Commitment: One 3 hour lab session per week for 4 weeks (during weeks 1-5 of term 3)

Assessment: 100% by written reports on each of the projects

Prerequisites: Most core 1st year mathematics modules, especially MA133 Differential Equations, MA131 Analysis, MA136 Abstract Algebra, MA124 Maths by Computer, and MA134 Geometry & Motion.

Leads To: MA259 Multivariable Calculus, MA209 Variational Principles, MA250 Partial Differential Equations, MA3J3 Bifurcation, Catastrophes and Symmetry

Content:
This module consists of a series of 4 laboratory projects which combine physical or computer experiments with mathematical modelling and analysis. The projects will include work on symmetry breaking, catastrophe theory, nonlinear oscillators, period doubling, and coupled pendula.

Much more information is provided on the Additional Resources page, linked below. Due to deregistration dates being before the start of the module, we strongly advise all students who are seriously considering taking the module to read this.

Aims:
To demonstrate that mathematical ideas and techniques can be used to predict and explain `real life' phenomena and that, conversely, physical intuition can lead to mathematical insights.

Objectives:

1. To show how various aspects of mathematics seen in earlier modules can be applied to real-world situations, such as the application of differential equations to the study of coupled and nonlinear oscillators.
2. To illustrate the use of simple group theoretical ideas in problems with symmetries.
3. To provide an opportunity for students to learn the thought process used to solve long and complicated problems, by breaking them down into smaller, more manageable pieces.
4. To provide an opportunity for students to develop report writing skills.
5. To provide an opportunity for students to develop the ability to work in groups.

Books:
As this module follows on from several core first year modules, you are recommended to check the recommended texts for those modules.

Additional Resources

Archived Pages: 2012 2014 2015

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA117 Programming for Scientists

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma117/)
Lecturer: Andrew Hague (DCS) and Khalil Challita (DCS)

Term(s): Term 2

Status for Mathematics students: List B for Maths

Commitment: 10 lectures plus lab sessions/tutorials

Assessment: Three programming assignments

Prerequisites: No previous computing experience will be assumed, but students should have obtained a code to use the IT Services work area systems prior to this module. Information and assistance is available in the Student Computer Centre in the Library Road

Leads to:

- MA4M1 Epidemiology by Example

Content: Aspects of software specification, design, implementation and testing will be introduced in the context of the Java language. The description of basic elements of Java will include data types, expressions, assignment and compound, alternative and repetitive statements. Program structuring and object oriented development will be introduced and illustrated in terms of Java's method, class and interface. This will enable the development of software that reads data in a variety of contexts, performs computations on that data and displays results in text and graphical form. Examples of iterative and recursive algorithms will be given. The importance of Java and Java Virtual Machine in networked computing will be described. The majority of examples will be standard applications but the development of Java Applets to be delivered by web browsers will also be covered.

Aims: To provide an understanding of the process of scientific software development and an appreciation of the importance of data vetting, sound algorithms and informative presentation of results.

Objectives: To enable the student to become confident in the use of the Java language for scientific programming.

Books:

Books are not essential for this module as use will be made of on-line tutorial and reference material. An informative, optional text is

H M Deitel & P J Deitel, *Java How to Program* (2nd or 3rd Ed), Prentice Hall.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA124 Mathematics by Computer

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma124/)
Lecturer: Richard Lissaman and Marya Bazzi

Term(s): Term 1 and 2

Status for Mathematics students: Core for Maths

Commitment: One lecture per week in term 1 weeks 1 - 3 and 8 - 10; two lectures per week in term 2 weeks 1 - 3, weekly support classes in same weeks in computing labs, a tutorial group project during terms 2 and start of term 3 (including a presentation at the end of term 2)

Assessment: Assessment will be via Moodle quizzes and assignments (50%) and the project (50%)

Formal registration prerequisites: None

Assumed knowledge: None, other than that already covered in core first-year mathematics modules

Useful background: Prior experience with Python or other programming languages will be useful

Synergies: The lectures, course resources and assessment will make contact with material from other first-year mathematics modules, in particular:

- MA141 Analysis 1
- MA139 Analysis 2
- MA146 Methods of Mathematical Modelling 1
- MA144 Methods of Mathematical Modelling 2
- MA132 Foundations
- MA151 Algebra 1
- MA150 Algebra 2

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA261 Differential Equations: Modelling and Numerics
- MA398 Matrix Analysis and Algorithms

- MA4M1 Epidemiology by Example

Python is a widely used programming language that is increasingly essential knowledge for mathematicians and scientists. Python underlies important mathematical software such as Sage. It dominates many modern applications, particularly in Data Science and Machine Learning.

Python is too vast to master in an introductory module of this size. Our goal is to rapidly introduce you to some of the most important aspects of Python for mathematical and scientific work. You will learn to use powerful libraries that carry out complex tasks and allow you to concentrate on the "big picture". By the end of the module you will find the computer to be a tool that can aid you throughout your life as a mathematician and, in particular, in many modules you will take at Warwick. You should think of your computing skills as a powerful resource to be used, potentially, at any time.

Aims:

The first aim is to show how the computer may be used, throughout all of mathematics, to enhance understanding, make predictions and test ideas.

Objectives:

The module will be taught using Python. Through using this language you will be introduced to the rudiments of computer programming.

You will learn how to graph functions, study vectors and matrices graphically and numerically, how to iterate and use iteration to study sequences and series, how to solve algebraic and differential equations numerically, how to use symbolic algebra in Python as well as some statistical techniques.

Books:

- M Lutz, *Learning Python*, O'Reilly Media Inc., 3rd edition, 2007, ebook here
- JV Guttag, *Introduction to Computation and Programming Using Python*, MIT Press, 2nd edition, 2016, ebook here

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA125 Introduction to Geometry

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma125/)
Lecturer: Meritxell Saez

Term(s): Not running 2021/22

Status for Mathematics students: List A for Maths

Commitment: Fifteen one-hour lectures

Assessment: One-hour exam taken in the summer term

Prerequisites:

Leads To: MA243 Geometry

Content: This module begins with a quick tour through elementary plane Euclidean geometry. We emphasise proof, and the careful use of diagrams as an aid to understanding problems and finding proofs. Plane geometry then provides the setting for an introduction to the geometry of the sphere and of polyhedra.

Aims:

- To learn and enjoy Euclidean geometry of the plane, the sphere and of three-dimensional space.
- To learn to visualise geometrical problems, and to draw diagrams which represent them accurately.

- To learn to reason from diagrams, and use them as an aid to writing rigorous proofs.
- To learn to construct proofs, and to set them out clearly and convincingly.

Objectives: You will gain familiarity with

- Plane Euclidean geometry: isometries, congruence and similarity; theorems on triangles, circles, tangents and angles; ruler and compass constructions.
- Polyhedra: the Euler characteristic; classification and construction of regular polyhedra.
- Spherical geometry: the angle-sum formula for spherical triangles; stereographic projection and its relation with inversion; conformal (angle-preserving) maps.

Books:

Notes for the module will be available at cost price from the departmental office.

Also relevant: G.A. Jennings, *Modern geometry with applications*, Springer-Verlag (a fine book with many challenging exercises, but useful only as a complement to the course).

Additional Resources

Archived Pages Pre-2011 2012 2016 2017

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA131 Analysis I and II

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma131/)
Lecturer:
Term 1: Daniel Ueltschi

Term 2: Keith Ball

Term(s): Terms 1 & 2

Status for Mathematics students: Core for Maths

CAUTION: This entry refers to arrangements for students based in the Mathematics Department (those who entered through the Mathematics Department and have a Personal Tutor there). All other students should be registered on MA137 Mathematical Analysis.

Commitment: One lecture per week, two 1-hour classes per week

Assessment: Weekly assignments (15%), January exam (25%), June exam (60%)

Formal registration prerequisites: None

Assumed knowledge: None

Useful background: None

Synergies: Analysis is one of the two most fundamental parts of pure mathematics with the other being algebra. This module forms the foundation on which many other modules will be built. Amongst the first year modules, the ones most closely related are: MA133 Differential Equations and MA134 Geometry and Motion. Analysis also has close connections to applied mathematics, probability theory and physics.

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA222 Metric Spaces

- MA260 Norms, Metrics and Topologies
- MA254 Theory of ODEs
- MA259 Multivariable Calculus
- MA4J1 Continuum Mechanics

Content: At the beginning of the nineteenth century, the familiar tools of calculus, differentiation and integration, began to run into problems. Mathematicians were unsure of how to apply these tools to sums of infinitely many functions. The origins of Analysis lie in their attempt to formalize the ideas of calculus purely in the the language of arithmetic and to resolve these problems.

You will study ideas of the mathematicians: Cauchy, Dirichlet, Weierstrass, Bolzano, D'Alembert, Riemann and others, concerning sequences and series in term one, continuity and differentiability in term two and integration in term one of your second year.

By the end of the year you will be able to answer many interesting questions: What do we mean by `infinity'? How can you accurately compute the value of π or e or $\sqrt{2}$? How can you add up infinitely many numbers, or infinitely many functions? Can all functions be approximated by polynomials?

There will be considerable emphasis throughout the module on the need to argue with much greater precision and care than you had to at school. With the support of your fellow students, lecturers and other helpers, you will be encouraged to move on from the situation where the teacher shows you how to solve each kind of problem, to the point where you can develop your own methods for solving problems. You will also be expected to question the concepts underlying your solutions, and understand why a particular method is meaningful and another not so. In other words, your mathematical focus should shift from problem solving methods to concepts and clarity of thought.

Books:
M. Hart, *Guide to Analysis*, Macmillan. (A good traditional text with theory and many exercises.)
K.G. Binmore, *Mathematical Analysis: A Straightforward Approach*, CUP (1982)

R.G Bartle and D.R Sherbert, *Introduction to Real Analysis*, (4th Edition), Wiley (2011)

L. Alcock, *How To Think About Analysis*, Oxford University Press (2014)

Recommended Syllabus

Additional Resources Analysis I (Term 1)

Additional Resources Analysis II (Term 2)

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA132 Foundations

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma132/)
Lecturer: Dave Wood

Term(s): Term 1

Status for Mathematics students: Core

Commitment: 30 lectures, assignments with weekly online quizzes based on them

Assessment: 15% from online quizzes and 85% from April exam

Formal registration prerequisites: None

Assumed knowledge: Grade A in A-level Maths or equivalent.

Useful background: Some elementary knowledge of modular arithmetic, induction principle, set notation.

Synergies: Most later pure mathematics modules specifically:

- MA139 Analysis 2
- MA150 Algebra 2
- MA268 Algebra 3

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA222 Metric Spaces
- MA260 Norms, Metrics and Topologies
- MA257 Introduction to Number Theory
- MA263 Multilinear Algebra
- MA3A6 Algebraic Number Theory
- MA3H3 Set Theory

Aims: University mathematics introduces progressively more and more abstract ideas and structures, and demands more and more in the way of proof, until by the end of a mathematics degree most of the student's time is occupied with understanding proofs and creating his or her own. This is not because university mathematicians are more pedantic than schoolteachers, but because proof is how one knows things in mathematics, and it is in its proofs that the strength and richness of mathematics is to be found.

Learning to deal with abstraction and with proofs takes time. This module aims to bridge the gap between school and university mathematics, by beginning with some rather concrete techniques where the emphasis is on calculation, and gradually moving towards abstraction and proof.

Indicative Content:

- **Naive Set Theory, Counting and Lists:**
  Sets and functions, injections, surjections and bijections, permutations.
  Lists, sublists, lists as functions, strings.
  Subsets, power sets, partition, infinite versus finite, Cantor's Theorem.
- **Operations on Sets, Lists, Functions:**
  Ordered pairs, cartesian products, functions and graphs, functions and lookup tables.
  Union, intersection, set difference, list concatenation.
  Composition, iteration, orbits, Cantor-Schroeder-Bernstein, cardinalities.
- **Relations:**
  Reflexive, symmetric, transitive.
  Orders, equivalence classes and relations: integers, rational numbers, partitions.
  Kernels and co-kernels, well-definedness, modular arithmetic.
- **Logic:**
  Variables, booleans, negation, operations.
  Operators and formulas via truth tables.
  Quantifiers, tautologies, deduction rules.
- **Proof:**
  What is proof? False proofs, examples, subtle issues (diagrams, hand-waving)
  Kinds of proof: direct, contraposition, contradiction, construction, cases.
  Recursion, induction, pigeonhole principle, counting.
- **Algorithms in Algebra and Cryptography:**
  What is algorithm? Euclid's algorithm, operational complexity, P=NP
  Discrete Logarithm, introduction to cryptography, Diffie-Hellman key exchange.
  Prime factorisation, primality testing, Chinese Remainder Theorem
  RSA (Rivest–Shamir–Adleman) public key exchange

Objectives: Students will work with number systems and develop fluency with their properties; they will learn the language of sets and quantifiers, of functions and relations and will become familiar with various methods and styles of proof.

Books:
None of these is the course text, but each would be useful, especially the first:
A.F.Beardon, *Algebra and Geometry*, CUP, 2005.
I.N. Stewart and D.O. Tall, *Foundations of Mathematics*, OUP, 1977.
J. A. Green, *Sets and Groups; First Course in Algebra*, Chapman and Hall, 1995.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

MA133 Differential Equations

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma133/)
Lecturer: Dwight Barkley

Term: Term 2

Status for Mathematics students: This module is not available to Maths students

Commitment: 30 lectures

Assessment: 15% from fortnightly assignments, 85% from a 2 hour examination

Formal registration prerequisites: None

Assumed knowledge: A-level mathematics or equivalent, in particular Calculus

Useful background: Proficiency with Mechanics from Maths A-level, or having taken Physics A-level, useful but not essential, we will cover necessary topics from first principles

Synergies: This module supports any module using differential or partial differential equations

Leads to: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA254 Theory of ODEs
- MA261 Differential Equations: Modelling and Numerics
- MA250 Introduction to Partial Differential Equations
- MA269 Asymptotics and Integral Transforms
- MA256 Introduction to Mathematical Biology
- MA258 Mathematical Analysis III
- MA209 Variational Principles
- MA390 Topics in Mathematical Biology
- MA3J3 Bifurcations, Catastrophes and Symmetry
- MA3H7 Control Theory
- MA4J1 Continuum Mechanics

Content: How do you reconstruct a curve given its slope at every point? Can you predict the trajectory of a tennis ball? The basic theory of ordinary differential equations (ODEs) as covered in this module is the cornerstone of all applied mathematics. Indeed, modern applied mathematics essentially began when Newton developed the calculus in order to solve (and to state precisely) the differential equations that followed from his laws of motion.

However, this theory is not only of interest to the applied mathematician: ideas from the theory of ODEs prove invaluable in various branches of pure mathematics, such as geometry and topology. The first half of this module will focus on ordinary differential equations - how to understand them and how to solve them. The second half of the module covers topics from multivariable calculus - partial derivatives, div, grad, curl, and some differential geometry and integration needed for subsequent modules on differential equations.

Aims: To introduce simple differential equations and methods for their solution and to provide a solid foundation in the calculus needed to study future modules involving ordinary and partial differential equations.

Objectives: You should be able to solve various simple differential equations (first order, linear second order and coupled systems of first order equations), be able to manipulate div, grad, and curl operations, and be able to integrate over simple curves and surfaces.

Books:

The primary text will be:

J. C. Robinson *An Introduction to Ordinary Differential Equations*, Cambridge University Press 2003.

J. Stewart, D. Clegg, S. Watson, *Multivariable Calculus, ninth edition, metric version*, Brooks/Cole 2022.

Additional references are:

W. Boyce and R. Di Prima, *Elementary Differential Equations and Boundary Value Problems*, Wiley 1997.

Recommended Syllabus

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA134 Geometry and Motion

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma134/)

Lecturer: Siri Chongchitnan and Thomas Hudson

Term(s): Term 2

Status for Mathematics students: Core for Maths

Commitment: 30 lectures

Assessment: 85% Examination, 15% Assessment

Formal registration prerequisites: None

Assumed knowledge: Vector identities involving dot and cross products, equations of circles, ellipses and hyperbolae in $\mathbb{R}^2$, polar coordinates and sketching polar curves, equations of lines and planes in $\mathbb{R}^3$, differentiation and integration techniques, Taylor expansion.

Useful background: Parametric curves in $\mathbb{R}^2$, Cartesian equations of simple surfaces (e.g. a sphere), plotting curves and surfaces in $\mathbb{R}^2$ and $\mathbb{R}^3$ online (e.g. math3d.org) or using Python

Synergies: MA133 Differential Equations and all Term 2 MA modules

Leads To: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA254 Theory of ODEs
- MA243 Geometry
- MA250 Introduction to Partial Differential Equations
- MA259 Multivariable Calculus
- MA269 Asymptotics and Integral Transforms
- MA4J1 Continuum Mechanics

This module leads on directly to MA259 Multivariable Calculus and, together with MA133 Differential Equations, provides the foundations for most future applied mathematics modules including MA250 Partial Differential Equations, MA209 Variational Principles. The geometric aspects of the module also lead on to MA3D9 Geometry of Curves and Surfaces. The proper theory of integration of functions of several variables is done in MA359 Measure Theory.

Content: When a particle moves in space, it traces out a curve as a function of time. This parametric description of a curve gives us an important connection between geometry and motion.

We will study parametric curves using the tools of *vector calculus*. We will also see how surfaces can be described parametrically using 2 parameters. The properties of curves, surfaces and volumes will be studied using partial differentiation and multiple integrals.

Aims: This module aims to indicate to students how intuitive geometric and physical concepts such as length, area, volume, curvature, mass, circulation and flux can be translated into mathematical formulas. It also aims to teach the practical calculation of these formulas and their application to elementary problems in particle/fluid mechanics.

Objectives: On successful completion of this module students should be able to:

- Parametrise simple curves and surfaces in cartesian and other coordinates, including polar, cylindrical and spherical coordinates
- Calculate lengths and curvatures of curves in R^3 and demonstrate that length is independent of parametrisation
- Understand and be able to calculate line, surface and volume integrals with respect to various coordinate systems. This includes change of variables and change of order of integration in repeated integrals
- Understand and prove simple properties of a conservative vector field
- State the Divergence and Stokes' Theorems and use them to aid calculations
- Apply all these techniques to problems in mechanics (mass, work, circulation and flux) and geometry (area, volume, centre of mass).

Books:

See the reading list on Talis.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

MA136 Introduction to Abstract Algebra

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ma136/)
Lecturer: Richard Lissaman

Term(s): Term 1

Status for Mathematics students: Core for Maths

Commitment: 15 one hour lectures

Assessment: Assignments (15%), Written exam (85%)

Formal registration prerequisites: None

Assumed knowledge: A-level Mathematics and Further Mathematics

Useful background: Some elementary knowledge of matrices, functions, modular arithmetic

Synergies:

- MA106 Linear Algebra
- MA132 Foundations or MA138 Sets and Numbers

Leads To: The following modules have this module listed as **assumed knowledge** or **useful background:**

- MA249 Algebra II
- MA251 Algebra I: Advanced Linear Algebra

- MA257 Introduction to Number Theory
- MA3F1 Introduction to Topology
- MA3E1 Groups and Representations
- MA4H4 Geometric Group Theory

Content:

Section 1 Group Theory:

- Motivating examples: numbers, symmetry groups
- Definitions, elementary properties
- Subgroups, including subgroups of Z
- Arithmetic modulo n and the group Z_n
- Lagrange's Theorem
- Permutation groups, odd and even permutations (proof optional)
- Normal subgroups and quotient groups

Section 2 Ring Theory:

- Definitions: Commutative and non-commutative rings, integral domains, fields
- Examples: Z, Q, R, C, Z_n, matrices, polynomials, Gaussian integers

Aims:

To introduce First Year Mathematics students to abstract Algebra, covering Group Theory and Ring Theory.

Objectives:

By the end of the module students should be able to understand:

- the abstract definition of a group, and be familiar with the basic types of examples, including numbers, symmetry groups and groups of permutations and matrices.
- what subgroups are, and be familiar with the proof of Lagrange's Theorem.
- the definition of various types of ring, and be familiar with a number of examples, including numbers, polynomials, and matrices.
- unit groups of rings, and be able to calculate the unit groups of the integers modulo n.

Books:

Any library book with Abstract Algebra in the title would be useful.

Additional Resources

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

ST114 Games and Decisions

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/st114/)
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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

EC106 Introduction to Quantitative Economics

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ec106/)

  

259 total students

40 total lecture hours

40 total contact hours

30 CATS - Department of Economics

Principal Aims

This module provides students who have a mathematical background with an introduction to both microeconomics and macroeconomics. It is taught using a non-mathematical approach, with the focus on providing an intuitive understanding to core economic theory, which will also include ‘real world’ applications. Graphical analysis will also be used to illustrate key concepts, giving students a different way of examining problems that will complement the mathematics skills learnt in other modules.

Play

00:00 / 02:05

Principal Learning Outcomes

Demonstrate knowledge of economic behaviours, outcomes, trends, developments, phenomena, institutions and policies

Demonstrate the capacity for abstract reasoning and to simplify economic problems through the application of theoretical models

Demonstrate an understanding of key concepts, principles, theories and models in Economics

Demonstrate the capacity to interpret economic data and to use data to inform the selection and application of appropriate economic tools of analysis

Demonstrate the capacity to comment and facilitate in formulating economic policy

Syllabus

Term 1: microeconomics, which is concerned with the economic behaviour of individual consumers and producing firms, and their interaction in markets for goods, services and factors of production, strategic interaction and the analysis of externalities and public goods. The module will typically consider some of the following topics:

What is Economics; Demand and Supply; Consumer Choice; Uncertainty; Information; Production; Costs; The Market Mechanism; Perfect Competition; Imperfect Competition, including Monopoly, Monopolistic Competition and Oligopoly; Game Theory; Market Failure, including Externalities and Public Goods

Term 2: macroeconomics, which is concerned with aggregate economic variables or the workings of the national economy as a whole: aggregate output (Gross Domestic Product or GDP), employment and unemployment, inflation, interest rates, the balance of payments, exchange rates, etc., and with government economic policies to influence these variables.

Introduction to Macroeconomics; Economic Growth; National Accounts, Alternative Measurements; The Distribution of Income; Aggregate Demand and Aggregate Supply; Equilibrium National Income; Inflation; Unemployment; The Phillips Curve; The Money Market; Interest Rates; The Financial System; ISLM analysis; The Great Depression; Economic and Financial Crises; The 3-Equation Model; Macroeconomic Policy; Technological Change; Models of Capital Accumulation; The Open Economy

Context

Core Module	G300 - Year 1, Y602 - Year 1
Optional Module	G100 - Year 1, G103 - Year 1
Pre or Co-requisites	A-level Mathematics or the equivalent

Assessment

Assessment Method	Coursework (20%) + Online Examination (80%)
Coursework Details	Online Examination (80%), Test 1 (10%), Test 2 (10%)
Exam Timing	Summer

Reading Lists

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

EC107 Economics 1

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/ec107/)

330 total students

40 total lecture hours

16 total seminars

56 total contact hours

30 CATS - Department of Economics

Principal Aims

This module allows students to develop an understanding of fundamental and intermediate concepts in micro and macroeconomic analysis by equipping them with a range of appropriate analytical skills, including descriptive, graphical and mathematical methods. This allows students to develop the capacity to apply analytical techniques to real world problems.

Play

00:00 / 02:11

Principal Learning Outcomes

Subject Knowledge and Understanding:... demonstrate knowledge of economic behaviours, outcomes, trends, developments, phenomena, institutions and policies.

Subject Knowledge and Understanding:...demonstrate an understanding of key concepts, principles, theories and models in Economics.

Subject Specific/Professional Skills:...demonstrate the capacity for abstract reasoning and to simplify economic problems through the application of theoretical models.

Subject Specific/Professional Skills:...demonstrate the capacity to interpret economic data and to use data to inform the selection and application of appropriate economic tools of analysis.

Syllabus

Typically, topics covered will include those such as:

Micro (term 1)

• The Capitalist Revolution

• Technology, Population and Growth

• Scarcity, Work and Choice

• Social Interactions

• Property and Power

• The Firm: Owners, managers and employees

• The Firm and its Customers

• Supply and Demand

• Markets, Efficiency and Public Policy

Macro (Term 2)

• Consumption, saving and investment.

• Aggregate demand, the multiplier and the IS curve

• The labour discipline model of equilibrium unemployment

• Wage setting, inflation and the Phillips Curve

• Social Preferences over inflation and unemployment, the central bank

• Monetary policy stabilisation: central bank responses to economic shocks

• Fiscal policy stabilisation

• Economic growth in historical and global perspective

• The Solow model of economic growth

Context

Core Module	LM1D (LLD2) - Year 1, V7ML - Year 1, GL11 - Year 1, GL12 - Year 1, L1L8 - Year 1, R9L1 - Year 1, R3L4 - Year 1, R4L1 - Year 1, R1L4 - Year 1, R2L4 - Year 1
Pre or Co-requisites	This module is available as an optional module for all students outside the Economics Department (except for WBS students) who have achieved a Grade B or better in Mathematics at A-level, or the equivalent. It is a pre-requisite for EC204: Economics 2 and EC238/EC239.

Assessment

Assessment Method	Coursework (30%) + Online Examination (70%)
Coursework Details	Assessment 1: Problem set (group work) Micro (5%), Assessment 2: MCQ Test (10%), Assessment 3: Problem set (group work) Macro (5%), Assessment 4: MCQ Test (10%), Online Examination (70%)
Exam Timing	Summer

Exam Rubric

Time Allowed: 3 Hours

Read all instructions carefully- and read through the entire paper at least once before you start entering your answers.

There are THREE Sections in this paper. Answer ALL questions in Section A (40 marks total). Answer TWO questions in Section B (30 marks total); and TWO questions in Section C (30 marks total).

Approved pocket calculators are allowed.

You should not submit answers to more than the required number of questions. If you do, we will mark the questions in the order that they appear, up to the required number of questions in each section.

Previous exam papers can be found in the University's past papers archive. Please note that previous exam papers may not have operated under the same exam rubric or assessment weightings as those for the current academic year. The content of past papers may also be different.

Reading Lists

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

CS126 Design of Information Structures

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/cs126/)

CS126-15 Design of Information Structures

Academic year	**22/23**
Department	**Computer Science**
Level	**Undergraduate Level 1**
Module leader	**Charilaos Efthymiou**
Credit value	**15**
Module duration	**10 weeks**

Assessment **Multiple**
Study location **University of Warwick main campus, Coventry**

Download as PDF

Description	Study	Assessment	Availability

Introductory description

CS126 is all about data structures and how to program them.

We are interested in: what common data structures exist; how we can program those data structures; how we can represent them efficiently; how we can reason about them (in a formal manner).
We are also interested in common algorithms that use data structures, including: searching for data; sorting data.

Module aims

The module aims for students to:

- gain familiarity with the specification, implementation and use of some standard abstract data types (ADTs) such as linked-lists, stacks, queues, graphs etc.
- learn some standard algorithms for common tasks (such as searching and sorting) and some elementary methods of measuring the complexity, and of showing the correctness, of algorithms;
- learn how to program with non-standard ADTs using an object-oriented language.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

- Types and their properties: simple types in programming languages; relationship between familiar mathematical and program objects of given type. Using predicate logic to state properties of types and their operations in terms of pre- and post-conditions.
- Abstract data types: specification of familiar abstract objects (eg complex numbers, sets, sequences, matrices) and their operations, comparison with their implementation using a typical programming language. Specification and implementation of some important standard types (eg strings, stacks and queues).
- Algorithms: relationship between data structures and algorithms; some standard algorithms for searching, sorting and pattern matching. Elementary analysis of complexity. Reasoning about the correctness of the implementation of simple algorithms.

Learning outcomes

By the end of the module, students should be able to:

- After completing CS126 Design of Information Structures, a student should be familiar with a range of standard ADTs and how they can be used to accomplish common programming tasks.
- After completing CS126 Design of Information Structures, a student should be able to assess the complexity and correctness of simple algorithms, and choose appropriate algorithms for simple tasks.
- After completing CS126 Design of Information Structures, a student should have practical experience of designing user-defined ADTs, and associated algorithms, for a non-standard application.

Indicative reading list

Please see Talis Aspire link for most up to date list.

View reading list on Talis Aspire

Subject specific skills

- Specifying abstract data types and implementing them in an object-oriented programming language
- Estimating the asymptotic running time of simple algorithms
- Using basic data structures to implement efficient algorithms

Transferable skills

- Creative problem solving

Year 1 regs and modules
G100 G103 GL11 G1NC

CS137 Discrete Mathematics and its Applications 2

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/cs137/)

CS147-10 Discrete Mathematics and Its Applications 2

Academic year	**22/23**
Department	**Computer Science**
Level	**Undergraduate Level 1**
Module leader	**Ramanujan Maadapuzhi Sridharan**
Credit value	**10**
Module duration	**10 weeks**
Assessment	**Multiple**
Study location	**University of Warwick main campus, Coventry**

Download as PDF

Description | Study | Assessment | Availability

Introductory description

This module is designed to introduce students to language and methods of the area of Discrete Mathematics.

Module aims

The focus of the module is on basic mathematical concepts in discrete maths and on applications of discrete mathematics in algorithms and data structures. One of the aims will be to show students how discrete mathematics can be used in modem computer science (with the focus on algorithmic applications).

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Big-Oh notation and its use in the analysis of algorithms.
Basic concepts from graph theory; such as trees, matchings, euler tours, colorings and cuts.
Applications of discrete probability; such as probabilistic method, random walks and entropy.

Learning outcomes

By the end of the module, students should be able to:

- Understand the notion of mathematical thinking, mathematical proofs, and algorithmic thinking, and be able to apply them in problem solving.
- Understand asymptotic notation, its significance, and be able to use it to analyse the runtimes of algorithms.
- Understand some basic properties of graphs and discrete probability, and be able to apply the methods from these subjects in problem solving.

Indicative reading list

To be finalised.

Subject specific skills

Basic knowledge of graph theory and its applications in algorithms
Basic knowledge of discrete probability and its applications in algorithms
Understanding and using asymptotic notations in design and analysis of algorithms

Transferable skills

Communication - Reading and writing mathematical proofs
Critical thinking - problem solving

Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

PX101 Quantum Phenomena

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/px101/)
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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

PX120 Electricity & Magnetism

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/px120/)
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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information

Core module averages

PX121 Thermal Physics I

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/px121/)

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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

PX144 Introduction to Astronomy

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/px144/)

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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages

PX147 Introduction to Particle Physics

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/px147/)

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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules

G103

Exam information
Core module averages

PX148 Classical Mechanics & Relativity

(https://warwick.ac.uk/fac/sci/maths/currentstudents/ughandbook/year1/px148/)

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Year 1 regs and modules
G100 G103 GL11 G1NC

Year 2 regs and modules
G100 G103 GL11 G1NC

Year 3 regs and modules
G100 G103

Year 4 regs and modules
G103

Exam information
Core module averages