

MA3L4-15 Numerical Analysis and Ordinary Differential Equations

26/27

Department

Warwick Mathematics Institute

Level

Undergraduate Level 3

Module leader

Bjorn Stinner

Credit value

15

Module duration

10 weeks

Assessment

Multiple

Study location

University of Warwick main campus, Coventry

Description

Introductory description

This module develops understanding of numerical methods that are used in many areas of the mathematical sciences, and it will improve Python programming skills.

[Module web page](#)

Module aims

Mathematical problems in science and engineering applications often do not yield to closed form analytic formulae but require numerical methods to learn about their solution. This module focuses on some basic approximation techniques for solving algebraic equations, interpolation and extrapolation, quadrature of functions, and for solving differential equations. Central to their convergence analysis are fundamental concepts, such as conditioning, stability, and consistency. Theoretical results are validated by implementing the methods and performing numerical simulations.

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.

Mathematical modelling in various applications in science and engineering can lead to problems that do not yield to closed form analytic solutions. Specifically, systems of nonlinear differential equations often cannot be explicitly integrated and thus require numerical methods to learn about solutions and their behaviour. This module is an introduction to such numerical approximation techniques and explains how, why, and when they can be expected to work. In particular, explicit and implicit Runge-Kutta and multistep methods will be discussed. The derivation of these methods and their implementation benefits from studying a wider range of related problems like polynomial interpolation of data points and its use to approximate functions, numerically differentiating functions with finite differences, integrating them using quadrature formulas, and solving algebraic problems with Newton's method. Fundamental concepts will be explained, namely conditioning of mathematical problems, but also consistency and stability of approximation techniques, which underpin the convergence analysis of approximation techniques. By implementing some methods theoretical convergence results will be validated.

Learning outcomes

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

- understand fundamental ideas that underpin numerical analysis
- derive and analyse fundamental numerical methods
- implement and test numerical methods using a scripting language

Indicative reading list

[Reading lists can be found in Talis](#)

[Specific reading list for the module](#)

Subject specific skills

Student will gain understanding of general principles that underpin the numerical analysis of approximation techniques.

Students will be comfortable in deriving, applying and evaluating approximation techniques involved in topics such as polynomial interpolation and extrapolation, numerical differentiation and integration.

Students will be able to numerically solve systems of ordinary differential equation using a variety of approximations methods and have a good understanding of the different properties of these methods.

This module will provide students with the foundations required for a wide range of topics in computational mathematics. The acquired skill set can then be applied to larger scale problems in various areas that require a mixture of robust and efficient numerical methods.

Transferable skills

Students will acquire key reasoning and problem solving skills which will empower them to address new problems with confidence. They will also gain the ability to use analytical and numerical methods (including associated programming knowledge) in harmony, enhancing capabilities in tackling complex challenges.

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Practical classes	10 sessions of 1 hour (7%)
Private study	110 hours (73%)
Total	150 hours

Private study description

Quizzes and assignments, engagement with departmental support and feedback mechanisms, exam preparation.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Assessment group C

	Weighting	Study time	Eligible for self-certification
Assessed coursework	50%		No
Several programming and theory based assignments and quizzes.			
Centrally-timetabled exam	50%		No

Assessment group R

	Weighting	Study time	Eligible for self-certification
Centrally-timetabled examination (on-	100%		No

campus)

Feedback on assessment

General and individual feedback provided for assessed coursework. Exam solutions.

[Past exam papers for MA3L4](#)

Availability

Courses

This module is Optional for:

- Year 3 of USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics

This module is Option list A for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
 - Year 4 of G105 Mathematics (MMath) with Intercalated Year
 - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- Year 3 of UMAA-G100 Undergraduate Mathematics (BSc)
- UMAA-G103 Undergraduate Mathematics (MMath)
 - Year 3 of G100 Mathematics
 - Year 3 of G103 Mathematics (MMath)
 - Year 4 of G103 Mathematics (MMath)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year

This module is Option list B for:

- Year 3 of USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics
- Year 3 of USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
- Year 3 of USTA-Y602 Undergraduate Mathematics, Operational Research, Statistics and Economics
- Year 4 of USTA-Y603 Undergraduate Mathematics, Operational Research, Statistics, Economics (with Intercalated Year)

This module is Option list C for:

- Year 3 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)