MA2L4-15 Numerical Analysis and Ordinary Differential Equations

26/27

Department
Warwick Mathematics Institute
Level
Undergraduate Level 2
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

	Weighting	Study time	Eligible for self-certification
campus)			

Feedback on assessment

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

Past exam papers for MA2L4

Availability

Courses

This module is Option list A for:

- Year 2 of UMAA-G100 Undergraduate Mathematics (BSc)
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 2 of G100 Mathematics
    - Year 2 of G103 Mathematics (MMath)
- Year 2 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 2 of USTA-GG14 Undergraduate Mathematics and Statistics (BSc)

This module is Option list B for:

- Year 2 of UCSA-G4G1 Undergraduate Discrete Mathematics
- UCSA-G4G3 Undergraduate Discrete Mathematics
    - Year 2 of G4G1 Discrete Mathematics
    - Year 2 of G4G3 Discrete Mathematics
- Year 2 of UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
    - Year 2 of GF13 Mathematics and Physics
    - Year 2 of FG31 Mathematics and Physics (MMathPhys)

This module is Option list C for:

- USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
    - Year 2 of G300 Mathematics, Operational Research, Statistics and Economics
    - Year 2 of Y602 Mathematics,Operational Research,Stats,Economics
- Year 2 of USTA-Y602 Undergraduate Mathematics,Operational Research,Statistics and Economics