MA2K4-10 Numerical Methods and Computing

23/24

Department
Warwick Mathematics Institute
Level
Undergraduate Level 2
Module leader
Tobias Grafke
Credit value
10
Module duration
10 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module develops understanding of the numerical methods and modelling techniques used in many areas of the mathematical sciences and will improve Python programming skills.

Module web page

Module aims

This module focuses on fundamental concepts of the analysis of numerical methods and mathematical modelling involving for example ordinary differential equations showcased using typical examples from physics, biology, and other areas of science and engineering. Basic numerical approximation methods will be presented including for example methods for solving systems of differential equations, the solution to algebraic equations, polynomial interpolation and .extrapolation, and quadrature. Concepts like stability, consistency, and convergence will be covered in this module, with the aim of introducing the approximation techniques used in tackling mathematical problems which do not yield to closed form analytic formulae. Other application will include for example graphics and visualization or medical imaging.

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.

Numerical approximations, Derivation of explicit and implicit Runge Kutta and multistep methods, Butcher tableau, Newton's method, polynomial interpolation/extrapolation, linear regression, optimization, and quadrature, stability, consistency, and convergence analysis.

Derivation and analysis of numerical methods for complex real word application is a focus of this module. Concepts like stability, consistency, and convergence will be covered in this module, with the aim of introducing the approximation techniques used in tackling mathematical problems which do not yield to closed form analytic formulae.
Basic numerical approximation methods will be presented for solving complex systems of differential equations like Runge-Kutta and multistep methods. The derivation and implementation of these methods will require studying a wide range of other approximation problems like polynomial interpolation, approximations to derivatives and integrals (finite differences and quadratures) and the solution to algebraic problems. Examples for the application of these methods will be taken from physics, biology but also for example from computer graphics/visualization, medical imaging.

Learning outcomes

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

- derive and analyse fundamental numerical methods
- implement and test numerical methods using a scripting language
- design and evaluate problem solving strategies for real-world application

Indicative reading list

D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing
L. N. Trefethen, Approximation Theory and Approximation Practice
E. Suli and D. F. Mayers, An Introduction to Numerical Analysis.
D. F. F. Griffiths and D. J. Higham, Numerical Methods for Ordinary Differential Equations,
T. Witelski, M. Bowen, Methods of Mathematical Modelling: Continuous System and Differential Equations,
R. L. Burden, J. D. Faires, A.M. Burden, Numerical Analysis,

Subject specific skills

You should understand the principles used to derive mathematical models of time dependent and stationary problems arising in scientific areas such as physics, chemistry and biology but also in medicine, economics, finance and social sciences. You should be comfortable in deriving, applying and evaluating approximation techniques involved in topics such as polynomial interpolation and extrapolation, numerical differentiation and integration. You should be able to solve systems of ordinary differential equation using different approximations methods and have a good understanding of the different properties of these methods. This module will provide you with the foundations required for a wide range of topics in applied and computational mathematics including mathematical modelling. The acquired skill set can then be applied to larger scale problems in specific interdisciplinary areas that require a mixture of robust mathematical 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

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Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (30%)
Online learning (independent)	9 sessions of 1 hour (9%)
Private study	21 hours (21%)
Assessment	40 hours (40%)
Total	100 hours

Private study description

Reviewing lectured material and accompanying supplementary materials; working on both summative and formative coursework.

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 A

	Weighting	Study time
Assessed coursework	100%	40 hours
Several programming or theory based assignments or quizzes.		

Assessment group R

	Weighting	Study time
Combined Assignment	100%	
Optional module, not suitable for reassessment.		

Feedback on assessment

General and individual feedback provided for assessed coursework

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Availability

Courses

This module is Option list A for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
  - Year 2 of G105 Mathematics (MMath) with Intercalated Year
  - Year 4 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G100 Undergraduate Mathematics (BSc)
  - Year 2 of G100 Mathematics
  - Year 2 of G100 Mathematics
  - Year 2 of G100 Mathematics
  - Year 3 of G100 Mathematics
  - Year 3 of G100 Mathematics
  - Year 3 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
  - Year 2 of G100 Mathematics
  - Year 2 of G103 Mathematics (MMath)
  - Year 2 of G103 Mathematics (MMath)
  - Year 3 of G100 Mathematics
  - Year 3 of G103 Mathematics (MMath)
  - Year 3 of G103 Mathematics (MMath)
- Year 2 of UMAA-G1NC Undergraduate Mathematics and Business Studies
- Year 2 of UMAA-G1N2 Undergraduate Mathematics and Business Studies (with Intercalated Year)
- Year 2 of UMAA-GL11 Undergraduate Mathematics and Economics
- Year 2 of UECA-GL12 Undergraduate Mathematics and Economics (with Intercalated Year)
- USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
  - Year 2 of GG14 Mathematics and Statistics
  - Year 2 of GG14 Mathematics and Statistics
- Year 2 of UMAA-G101 Undergraduate Mathematics with Intercalated Year

This module is Option list B for:

- UCSA-G4G1 Undergraduate Discrete Mathematics
    - Year 2 of G4G1 Discrete Mathematics
    - Year 2 of G4G1 Discrete Mathematics
- Year 2 of UCSA-G4G3 Undergraduate Discrete Mathematics
- USTA-Y602 Undergraduate Mathematics,Operational Research,Statistics and Economics
    - Year 2 of Y602 Mathematics,Operational Research,Stats,Economics
    - Year 2 of Y602 Mathematics,Operational Research,Stats,Economics