MA261-12 Differential Equations: Modelling and Numerics

20/21

Department
: Warwick Mathematics Institute

Level
: Undergraduate Level 2

Module leader
: David Wood

Credit value
: 12

Module duration
: 10 weeks

Assessment
: Multiple

Study location
: University of Warwick main campus, Coventry

Description

Introductory description

N/A

[Module web page]

Module aims

This module focuses on fundamental concepts of mathematical modelling involving ordinary differential equations and their numerical solution. Modelling concepts such as conservation and dissipation principles, calculus of variations, and non dimensionalisation will be covered using typical examples from physics, biology, and other areas of science and engineering. Basic numerical approximation methods will be presented for solving the resulting systems of differential equations like Runge-Kutta and multistep methods. 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.

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.

Concepts of Mathematical Modelling, e.g. conservation and dissipation principle, dimensional analysis, non dimensionalization,
asymptotic expansion, introduction to calculus of variations, minimization, Hamiltonian dynamics, Lagrange multipliers, inverse and optimal control problems, gradient flow Numerical approximations Derivation of explicit and implicit Runge Kutta and multistep methods, Butcher tableau, Newton's method, polynomial interpolation and quadrature, stability, consistency, and convergence analysis.

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Learning outcomes

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

- - Implement and test numerical methods using a scripting language
- - Understand the central concepts of mathematical modelling
- - Be able to derive and analyse fundamental numerical methods

Indicative reading list

D. F. F. Griffiths and D. J. Higham, Numerical Methods for Ordinary Differential Equations: Initial Value
Problems, Springer (2010)
T. Witlski, M.Brown, Methods of Mathematical Modelling: Continuous System and Differential Equations,
Springer (2015)
R. L. Burden and J. D Faires, Numerical Analysis, 8th edition, Brooks-Cole Publishing (2004).

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 economics, finance and social sciences. Also you should be able to solve the resulting 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.

Transferable skills

Students will acquire key reasoning and problem solving skills which will empower them to address new problems with confidence.

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (25%)
Tutorials	9 sessions of 1 hour (8%)
Private study	81 hours (68%)
Total	120 hours

Private study description

81 hours self-working: reviewing lectured material and accompanying supplementary materials; working on both summative and formative coursework; revising for exams.

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%	

Assessment group R

	Weighting	Study time
No reassessment required - please omit	100%	
Please note - No reassessment required		

Feedback on assessment

General and individual feedback provided for assessed coursework

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Availability

Courses

This module is Optional for:

- Year 3 of UMAA-GL11 Undergraduate Mathematics and Economics
- USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
    - Year 2 of G1G3 Mathematics and Statistics (BSc MMathStat)
    - Year 3 of G1G3 Mathematics and Statistics (BSc MMathStat)
    - Year 4 of G1G3 Mathematics and Statistics (BSc MMathStat)
- Year 4 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
- USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
    - Year 2 of GG14 Mathematics and Statistics
    - Year 2 of GG14 Mathematics and Statistics

This module is Core option list B for:

- Year 3 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

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 3 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)

- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
    - Year 2 of G106 Mathematics (MMath) with Study in Europe
    - Year 3 of G106 Mathematics (MMath) with Study in Europe
- 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)
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
    - Year 3 of GF13 Mathematics and Physics
    - Year 3 of GF13 Mathematics and Physics
- UMAA-G101 Undergraduate Mathematics with Intercalated Year
    - Year 2 of G101 Mathematics with Intercalated Year
    - Year 4 of G101 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-GG14 Undergraduate Mathematics and Statistics (BSc)
    - Year 3 of GG14 Mathematics and Statistics
    - Year 3 of GG14 Mathematics and Statistics
- Year 4 of USTA-GG17 Undergraduate Mathematics and Statistics (with Intercalated Year)