ES4C3-15 Mathematical and Computer Modelling

24/25

Department
School of Engineering
Level
Undergraduate Level 4
Module leader
Igor Khovanov
Credit value
15
Module duration
10 weeks
Assessment
100% coursework
Study location
University of Warwick main campus, Coventry

Description

Introductory description

ES4C3-15 Mathematical and Computer Modelling

Module web page

Module aims

To provide the theoretical background to basic and advanced modelling techniques and computational methods as used in engineering and to provide the necessary software application skills for using the techniques and methods in Matlab environment.

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.

Introduction to Modelling and Problem Solving Techniques
o Computers and Software. Approximations and errors
o Linear versus nonlinear systems: Linear and Non-linear resonance, Self-oscillations, Bifurcations

- Data driven models
  o Interpolation and Extrapolation
  o Least-squares regression
  o Curve fitting
- Roots of nonlinear equation
  o Bracketing methods
  o Open methods
- Computational differentiation and integration
  o Finite-difference approximation of derivatives
  o Computation of derivatives via interpolation and extrapolation
  o Newton-Cotes versus Gauss quadrature
- Numerical solution of ordinary differential equations
  o Initial value problem
  o Boundary value problem
- Partial-Differential Equations
  o Classification, initial and boundary conditions
  o Finite-difference methods
  o Iterative methods for solution of linear matrix equation and their application for solving partial differential equations
  o Finite-element approach

Each topic includes illustrative examples and templates of Matlab scripts for relevant modelling and computational techniques.

Learning outcomes

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

- 1. Built or select mathematical models over a wide range of application areas in engineering [M1, M2, M3].
- 2. Intelligently select and use suitable computational methods and software systems for engineering tasks [M3].
- 3. Evaluate the principles, purpose, and limitations of models and computational methods used in engineering software [M1, M2, M3].
- 4. Implement, evaluate and use key computational methods in a Matlab environment [M3, M12].

Indicative reading list

1. Jaan Kiusalaas, “Numerical methods in engineering with MATLAB”, Cambridge Press, 2010, e-book format.
2. A. Gialt and V. Subramaniam, “Numerical methods for engineers and scientists: An introduction with Applications using MATLAB”, New York : Wiley, 2008.
3. S.S. Rao, Applied Numerical Methods for Engineers and Scientists, Prentice Hall, 2002.
4. Won Young Yang and others, Applied numerical methods using MATLAB, Willey, 2005, e-book format.
5. Steven H. Strogatz, Nonlinear dynamics and chaos : with applications to physics, biology,

chemistry, and engineering, Westview Press, 2015, e-book format.
6. Douglas Thorby, Structural dynamics and vibration in practice : an engineering handbook, Elsevier, 2008, e-book format.

Research element

Providing an overview of new development in engineering modelling. Using research project and research outcome as examples in the teaching to show how research contributes in engineering development.

Subject specific skills

Ability to integrate analytical, mathematical and programming skills for analysing, developing and critically evaluating mathematical engineering models.
Ability to be pragmatic, taking a systematic approach and the logical and practical steps necessary for complex concepts to become a reality.
Ability to apply the knowledge of specific software package for engineering modelling.
Ability to understand typical simple nonlinear models and their place in engineering design.
Appreciation of the global dimensions of engineering modelling and its connections to the Industry 4 revolution.

Transferable skills

Ability to overcome difficulties by employing skills, knowledge and understanding in a flexible manner.
Ability to apply mathematical and computational methods to communicate parameters, model and optimise solutions.
Ability to apply problem-solving skills, information retrieval, and the effective use of specific software packages and general IT facilities.
Ability to plan self-learning and improve performance as the foundation for lifelong learning and continuous professional development.

Study

Study time

Type	Required
Lectures	16 sessions of 1 hour (11%)
Practical classes	5 sessions of 3 hours (10%)
Other activity	2 hours (1%)
Private study	117 hours (78%)
Total	150 hours

Private study description

117 hours guided independent learning.

Other activity description

2 x 1hr revision classes

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group A3

	Weighting	Study time
Assignment - Lab	30%	
Template-based assignment (includes Matlab code), completed in the lab sessions.		
Computer Modelling Assignment	70%	
Assignment following template with 14 pages.		

Feedback on assessment

- Support through advice and feedback hours.
- Written feedback on assignment and coursework.
- Cohort-level feedback on assignment and coursework.

Availability

Courses

This module is Core for:

- Year 4 of UESA-HH31 MEng Systems Engineering
- Year 4 of UESA-HH33 MEng Systems Engineering with Exchange Year
- Year 5 of UESA-HH32 MEng Systems Engineering with Intercalated Year

This module is Optional for:

- Year 4 of UESA-H116 MEng Engineering with Exchange Year
- Year 5 of UESA-H115 MEng Engineering with Intercalated Year
- RESA-H6P9 Postgraduate Research Wide Bandgap Power Electronics
    - Year 1 of H6P9 Wide Bandgap Power Electronics (EngD)
    - Year 2 of H6P9 Wide Bandgap Power Electronics (EngD)
- Year 1 of TESA-H341 Postgraduate Taught Advanced Mechanical Engineering
- TESA-H1B1 Postgraduate Taught Predictive Modelling and Scientific Computing
    - Year 1 of H1B1 Predictive Modelling and Scientific Computing
    - Year 2 of H1B1 Predictive Modelling and Scientific Computing

This module is Option list A for:

- Year 4 of UESA-H163 MEng Biomedical Systems Engineering
- Year 4 of UESA-H114 MEng Engineering
- UESA-H311 MEng Mechanical Engineering
    - Year 4 of H311 Mechanical Engineering
    - Year 4 of H30J Mechanical Engineering with Appropriate Technology
    - Year 4 of H30L Mechanical Engineering with Automotive Engineering
    - Year 4 of H30K Mechanical Engineering with Instrumentation
    - Year 4 of H30M Mechanical Engineering with Robotics
    - Year 4 of H30N Mechanical Engineering with Systems Engineering
- Year 4 of UESA-H316 MEng Mechanical Engineering
- Year 4 of UESA-H318 MEng Mechanical Engineering with Exchange Year
- Year 5 of UESA-H317 MEng Mechanical Engineering with Intercalated Year
- Year 1 of TESA-H643 Postgraduate Taught Electrical Power Engineering
- Year 1 of TESA-H642 Postgraduate Taught Energy and Power Engineering

This module is Option list B for:

- UESA-H311 MEng Mechanical Engineering
    - Year 4 of H30G Mechanical Engineering with Business Management
    - Year 4 of H30P Mechanical Engineering with Fluid Dynamics
    - Year 4 of H30H Mechanical Engineering with Sustainability
- Year 4 of UCSA-G408 Undergraduate Computer Systems Engineering
- Year 5 of UCSA-G409 Undergraduate Computer Systems Engineering (with Intercalated Year)