MODULE TITLE	**Modelling: Theory and Practice**	**CREDIT VALUE**	**30**
MODULE CODE	**MTH2005**	**MODULE CONVENER**	**Dr Stephen Thomson (Coordinator)**

DURATION: TERM	**1**	**2**	**3**
DURATION: WEEKS	**11**	**11**	**0**

Number of Students Taking Module (anticipated)	**128**

DESCRIPTION - summary of the module content

The role of the mathematician has changed significantly with the advent and increasing processing power of modern computers. This module develops the theoretical and practical skills necessary to develop and apply numerical methods of solution, using a computer package such as Matlab. Drawing on techniques learned in the first year, in this module you will analyse the underpinning mathematics and the practical coding challenges appropriate to applying them compute solutions to problems in a variety of situations. For part of the module you will work together within groups to develop and analyse your own computer models. You will study the performance of underlying algorithms and the limits to their predictive power. Specifically, you will study approximation methods for root finding, optimization, integration and solution of differential equations. The skills developed here will be useful for modules such as MTH3039 Computational Nonlinear Dynamics and more generally for coding and simulation in any application area of scientific computing.

Prerequisite modules: MTH1003 or NSC1002 (Natural Science Students) or equivalent.

Corequisite module: MTH2003.

AIMS - intentions of the module

This module explores the use of computers to solve mathematical problems by means of numerical approximation. The techniques discussed form the basis of the numerical simulation and computer modelling of problems in science and business. The key aim is developing an understanding of the numerical algorithms and we will explore these both theoretically and through case studies that develop further the mathematical modelling techniques learned in MTH1003.

INTENDED LEARNING OUTCOMES (ILOs) (see assessment section below for how ILOs will be assessed)

On successful completion of this module, **you should be able to:**

Module Specific Skills and Knowledge:

1 demonstrate a working knowledge of the theory and practical implementation of basic numerical methods;

2 explore applications and ideas underpinning more advanced methods that are developed in third/fourth stage modules and project work;

3 develop and code your own mathematical models with guidance;

4 interpret the outputs from your models, drawing suitable conclusions from your data;

5 evaluate the effectiveness of your models at explaining and predicting the phenomena you are modelling.

Discipline Specific Skills and Knowledge:

6 explore the subject material of the module through diverse applications to areas of science and business;

7 use computation as a natural method for tackling such problems;

Personal and Key Skills

8 demonstrate theoretical and practical mathematical skills, including programming.

9 formulate and solve problems independently;

10 communicate computer results and mathematical derivations effectively.

11 work in teams and use a variety of sources to produce reports and other appropriate scientific outputs.

SYLLABUS PLAN - summary of the structure and academic content of the module

Root Finding

Bisection, Newton-Raphson and fixed point convergence. Proofs of convergence and non-convergence. Demonstration of convergence and non-convergence using diagrams.

Quadrature and Ordinary Differential Equations (ODEs)

Finite differences, including first and second-order approximations for both the first and second derivative. Timestepping of a first-order ODE using the following methods: forward Euler, leap-frog, Runga-Kutta, Implicit, Adams-Bashforth and Adams-Moulton. Understanding of numerical stability, including identifying the true solution. Analysis of both accuracy and stability of timestepping methods.

Matrices

The LU decomposition and Gaussian elimination for matrix inversion. Iterative matrix inversion methods: Jacobi, Gauss-Seidel and Successive Over Relaxation. Analysis of convergence of the iterative methods using: (1) method of norms and (2) Spectral radius. The condition number. Calculating eigenvalues using the power method.

Partial Differential Equations (PDEs)

1d diffusion and 1d advection equation as prototypical PDEs. Finite difference methods. Implicitness and possible extensions e.g. semi-lagrangian and montone advection.

Case studies will be developed in a variety of areas of mathematics, science and/or business as part of the coursework, to support and enhance the material formally presented in lectures/tutorials. These case studies might include, for example: optimisation; Fast Fourier Transform; stochastics; modelling of data.

LEARNING AND TEACHING

LEARNING ACTIVITIES AND TEACHING METHODS (given in hours of study time)

Scheduled Learning & Teaching Activities	64.00	Guided Independent Study	236.00	Placement / Study Abroad	

DETAILS OF LEARNING ACTIVITIES AND TEACHING METHODS

Category	Hours of study time	Description
Scheduled learning and teaching activities	44	Lectures
Scheduled learning and teaching activities	10	Practicals in a computer lab
Scheduled learning and teaching activities	10	Tutorials
Guided independent study	236	Lecture and assessment preparation; wider reading

ASSESSMENT

FORMATIVE ASSESSMENT - for feedback and development purposes; does not count towards module grade

Form of Assessment	Size of Assessment (e.g. duration/length)	ILOs Assessed	Feedback Method
Exercise sheets	5 x 5 hours	All	Discussion in tutorials; model solutions where appropriate.

SUMMATIVE ASSESSMENT (% of credit)

Coursework	70	Written Exams	30	Practical Exams	

DETAILS OF SUMMATIVE ASSESSMENT

Form of Assessment	% of Credit	Size of Assessment (e.g. duration/length)	ILOs Assessed	Feedback Method
Written exam – closed book	30	2 hours (Summer)	1-10	Via SRS
Case study 1	20	5000 words or equivalent	All	Written comments on returned coursework, customized marksheet
Case study 2	20	5000 words or equivalent	All	Written comments on returned coursework, customized marksheet
Project (group)	30	7500 words or equivalent	All	Written comments on returned coursework, customized marksheet

DETAILS OF RE-ASSESSMENT (where required by referral or deferral)

Original Form of Assessment	Form of Re-assessment	ILOs Re-assessed	Time Scale for Re-reassessment
Written exam *	Written exam (2 hours) (30%)	1-10	August Ref/Def period
Case Study 1 *	Case Study 1 (20%)	All	August Ref/Def period
Case Study 2 *	Case Study 2 (20%)	All	August Ref/Def period
Project (group) *	Individual assessment (30%)	All	August Ref/Def period

*Please refer to reassessment notes for details on deferral vs. Referral reassessment

RE-ASSESSMENT NOTES

Deferrals: Reassessment will be by coursework and/or written exam in the deferred element only. For deferred candidates, the module mark will be uncapped.
Referrals: Reassessment will be by a single written exam worth 100% of the module only. As it is a referral, the mark will be capped at 50%.

RESOURCES

INDICATIVE LEARNING RESOURCES - The following list is offered as an indication of the type & level of information that you are expected to consult. Further guidance will be provided by the Module Convener

ELE – http://vle.exeter.ac.uk

Reading list for this module:

Type	Author	Title	Edition	Publisher	Year	ISBN	Search
Set	Kharab, A. and Guenther, R.B.	An Introduction To Numerical Methods: A MATLAB Approach		Chapman & Hall	2012	978-1439868997	[Library]
Set	Iserles A.	A first course in numerical analysis of differential equations		Cambridge University Press	1996	000-0-521-55376-8	[Library]
Set	Gerald C.F. & Wheatley P.O.	Applied Numerical Analysis	7th	Anderson-Wesley	2004	978-8131717400	[Library]
Set	Adby, P.R. & Dempster, M.A.H	Introduction to Optimization Methods		Chapman & Hall	1974	0-412-11040-7	[Library]
Set	Press, W.H., Flannery, B.P., Teukolsky, S.A. & Vetterling, W.T	Numerical Recipes: the Art of Scientific Computing	3rd edition	Cambridge University Press	2007	13: 9780521880688	[Library]
Set	Yang, X-S	Introduction to Computational Mathematics		World Scientific	2008	13-978-981-281-81	[Library]

CREDIT VALUE	30	ECTS VALUE	15

PRE-REQUISITE MODULES	MTH1002, MTH1003
CO-REQUISITE MODULES	MTH2003

NQF LEVEL (FHEQ)	5	AVAILABLE AS DISTANCE LEARNING	No
ORIGIN DATE	Tuesday 10 July 2018	LAST REVISION DATE	Friday 03 February 2023

KEY WORDS SEARCH	Numerical analysis; differential equations; optimisation; minimisation; matrices; Gaussian elimination; MATLAB; case studies.