MODULE TITLE	**Statistical Computing**	**CREDIT VALUE**	**15**
MODULE CODE	**MTH3045**	**MODULE CONVENER**	**Dr Ben Youngman (Coordinator)**

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

Number of Students Taking Module (anticipated)	**45**

DESCRIPTION - summary of the module content

When we want to fit a statistical model to some data it is almost inevitable that a computer will make this process much easier. Computers can speed up calculations, avoid the tedium or potential for error of doing calculations by hand, and have allowed us to analyse amounts of data and fit new models that were simply impractical without them. Data Science is built on the fitting of statistical models to data. While such models continue to evolve, we must balance what's theoretically and practically possible; otherwise we have data that we can't analyse and models that we can't estimate. We can achieve more by fitting statistical models efficiently.

To efficiently fit statistical models, we often use fundamental mathematical concepts, including some that you will have previously seen, such as matrix decompositions. You will learn a variety of these concepts from the theory behind them to their role in analysing real-life data. You will see some important statistical models that rely on these concepts and how the R programming language can be used for computation, in particular some of its more advanced features for calculations and analysing data. You will gain experience in programming while learning new statistical methods and models, through interesting examples and exercises. After this module you will be able to analyse more complex data with more advanced statistical techniques.

MTH2006 or equivalent is a prerequisite for this module. You may find MTH3041 and MTH3028 helpful and/or of interest.

AIMS - intentions of the module

This module aims to help you develop advanced computational and mathematical skills for the statistical analysis of data, which are essential for advanced Data Science. The module will introduce important mathematical concepts and their place in efficiently fitting statistical models or contributing to new statistical models that let us better analyse data. Such skills and models are important for statistical research and for jobs that heavily involve statistical analysis, such as a Data Scientist.

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 an understanding of important mathematical concepts, such as matrix decompositions and optimisation algorithms, and their role in fitting statistical models;
2. apply these concepts to the fitting of various statistical models to data;
3. employ these concepts and fit statistical models to data using the programming language R;
4. demonstrate and compare fitting approaches for computational efficiency;

Discipline Specific Skills and Knowledge

5. demonstrate an understanding of using computers to fit statistical models to data;
6. progress to study a wider range of computational tools and/or statistical methodology;

Personal and Key Transferable / Employment Skills and Knowledge:

7. demonstrate an understanding of key computational aspects when fitting statistical models for the advanced study, application and development of statistical and data science.

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

Background in statistical computing: How computers perform calculations, efficiency in computation; computing with programming language R; compiled computer code; debugging, benchmarking and profiling.
Matrix-based computing: Fundamentals of matrices and matrix-based calculations; systems of linear equations; matrix decompositions; statistical applications, e.g. principal components, multivariate normal calculations.
Optimisation: One-dimensional optimisation; multi-dimensional optimisation, including variants of Newton's method; global optimisation; statistical applications, e.g. non-linear model fitting and uncertainty estimation.
Numerical calculus: Numerical and symbolic differentiation; Monte Carlo integration, quadrature, Laplace's method; statistical applications, e.g. the integrated Laplace approximation.
Advanced numerical and statistical methods: E.g. approximate Bayesian computation; discrete and fast Fourier transforms.

LEARNING AND TEACHING

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

Scheduled Learning & Teaching Activities	31.00	**Guided Independent Study**	119.00	**Placement / Study Abroad**	

DETAILS OF LEARNING ACTIVITIES AND TEACHING METHODS

Category	Hours of study time	Description
Scheduled learning and teaching activities	31	Lectures/example classes
Guided independent study	119	Guided independent study

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

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Coursework - example sheets	5 exercise sheets	All	Tutorial sessions during lectures/office hours, written feedback on work

SUMMATIVE ASSESSMENT (% of credit)

Coursework	0	Written Exams	50	Practical Exams	50

DETAILS OF SUMMATIVE ASSESSMENT

Form of Assessment	% of Credit	Size of Assessment (e.g. duration/length)	ILOs Assessed	Feedback Method
Coursework 1	50	12 pages	All	Written
Practical exam	50	3 hours (Summer)	All	Written

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-assessment
Practical exam *	Examination (3 hours) (50%)	All	August Ref/Def period
Coursework 1 and/or 2 *	Reassessment coursework (50%)	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 exam worth 100% of the module only. As it is a referral, the mark will be capped at 40%.

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	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	Wickham, H.	Advanced R		Chapman and Hall	2014	978-1466586963	[Library]
Set	Wood, S N	Core Statistics	2	Cambridge University Press	2015		[Library]
Set	Monahan, J F	Numerical Methods of Statistics	2	Cambridge University Press			[Library]

CREDIT VALUE	15	ECTS VALUE	7.5
PRE-REQUISITE MODULES	MTH2006		
CO-REQUISITE MODULES			
NQF LEVEL (FHEQ)	6	AVAILABLE AS DISTANCE LEARNING	No
ORIGIN DATE	Tuesday 09 March 2021	LAST REVISION DATE	Thursday 01 February 2024
KEY WORDS SEARCH	Numerical optimisation; matrix computations; statistical models		