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APPROVED

MATH 9974: Biomathematics

Module Details

Module Code:	MATH 9974
Module Long Title:	Biomathematics APPROVED
Banner Title:	Biomathematics
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Sept 2023 (September 2023)
Language of Instruction:	English
ECTS Credits::	10
ISCED Code:	0541 - Mathematics
Current Coordinator::	JOHN BUTLER
Module Coordinators:	JOHN BUTLER (10 June 2022 to ---)
School Responsible:	School of Mathematics & Statistics
Campus:	City Campus
Module Overview	This module introduces the students to practical application of mathematical models as a tool for exploration of the underlying mechanisms involved in biological processes. No previous knowledge of biology is assumed for this module. With each discussed topic a brief description of the biological background sufficient to understand the studied model is given. The course is supposed to be of interest to people whose primary motivation is to learning mathematical modeling applied to a wide range of biological problems. The module covers various aspects of single population models, including both continuous and discrete models as well as the interaction of several populations. The basic results in this area are illustrated with numerous important examples. This module is designed to be relevant to postgraduate students in the area of mathematical sciences.
Learning and Teaching Methods	This module is delivered through Blended Learning with a mix of synchronous and asynchronous online lectures and tutorials. Online delivery may use a flipped classroom approach, with pre-recorded material viewed in conjunction with synchronous sessions. There may be the occasional pre-planned in-person on-campus lecture/tutorial. Students will be required to undertake background reading and self-directed learning. The self-directed learning hours will be devoted to preparing for lectures, undertaking solutions to tutorials sheets, reflecting upon the lecture material, refining and deepening understanding and consolidating individual learning.

Indicative Syllabus
1. Overview of mathematical models in Biosciences 1.1) Introduction to the subject area.
2. Continuous population models for single species 2.1) Growth models; insect outbreak models; delay models.
3. Population models with spatial distributions. 3.1) Fischer-Kolmogoroff model, Reaction-Diffusion models in one and two dimensions.
4. Discrete population models for single species. 4.1) Stability analysis, periodic solutions, bifurcation and chaos
5. Introduction to the theory of two component dynamical systems 5.1) Critical points, stability, phase portraits.
6. Continuous models for interacting populations 6.1) Predator-prey models, competition models, symbiosis.

Module MATH 9974 - Biomathematics v1 (Year/Cycle:1 / Semester:Semester 1 / Delivery Type:Mandatory)

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Explain the fundamentals of mathematical models in Biological sciences.
MLO2	Describe how the rate of growth or decay of an isolated population is determined in terms of birth and death processes.
MLO3	Demonstrate practical skills of modelling applied to Biomathematics and critically evaluate the mathematical methods required to obtain exact or approximate quantitative solutions.
MLO4	Investigate some of the pitfalls of indiscriminate, naïve or uninformed use of models.
MLO5	Perform computations using algebra, calculus and differential equations methods in the model equations arising in this subject area.

Requisites	
Assessment Threshold	A minimum mark of 35% must be achieved on both components.

Module Content & Assessment

Assessment Breakdown	%
Formal Examination	60.00%
Other Assessment(s)	40.00%

Assessments

Formal Examination

Assessment Type	Written Examination	**% of Total Mark for Module**	60
Indicative Week	Week 14	**Learning Outcomes**	1,2,3,4,5
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
End of Semester Exam

Other Assessment(s)

Assessment Type	Problem-Based Assignment	**% of Total Mark for Module**	40
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
Continuous assessment

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	39
Self Directed	161
Hours (up to 100 for 5 ECTS credits)	200.00

Recommended Reading List

Recommended Book Resources

James D. Murray. (2007), Mathematical Biology, Springer Science & Business Media, [ISBN: 978-0-387-22437-4].

James D. Murray. (2011), Mathematical Biology II, Springer, [ISBN: 0387952284].

Elizabeth S. Allman,Elizabeth S Allman,John A. Rhodes. (2004), Mathematical Models in Biology, Cambridge University Press, [ISBN: 0521525861].

Supplementary Book Resources

Nicholas Britton. (2005), Essential Mathematical Biology, Springer Science & Business Media, [ISBN: 185233536X].

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MATH 9956: Introduction to Mathematical & Statistical Case Studies

Module Details

Module Code:	MATH 9956
Module Long Title:	Introduction to Mathematical & Statistical Case Studies APPROVED
Banner Title:	Introduction to Mathematical & Statistical Case Studies
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Jan 2022 (January 2022)
Language of Instruction:	English
ECTS Credits::	10
ISCED Code:	0541 - Mathematics
Current Coordinator::	JOHN BUTLER
Module Coordinators:	JOHN BUTLER (10 June 2022 to ---)
School Responsible:	School of Mathematics & Statistics
Campus:	City Campus
Module Overview	This module introduces and lays the foundation to mathematical and statistical research which is problem oriented instead of topic oriented and gives experience with formulating and analysing data arising from practical problems in scientific, engineering or industrial settings using mathematical and statistical methods. The module will be divided into 2 problems/case studies chosen from different application of applied mathematical and statistical methods. For each case study that is considered, all stages of modelling lifecycle will be discussed, including model formulation, methodology and approach (including limitations, challenges), data wrangling, data visualization and analysis and interpretation of solutions and results.
Indicative Syllabus	The module will follow the modelling of two or three problems chosen as distinct case studies. The case studies will require the application of mathematical and statistical knowledge and skills and the communication of the findings in an appropriate format for dissemination.

Learning and Teaching Methods	This module is delivered through Blended Learning with a mix of pre-planned in-person on-campus/ online discussion-based lectures and computer lab sessions. Students work on case studies as part of a team and on an individual basis. Substantial background reading and self-directed learning is required for this module, including the preparation and presentation of a written report for each case study. In addition to the Essential Reading list, other textbooks (or research articles) will be specified on an annual basis at the start of the module, depending on the topics to be covered.

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Identify and select the variables in various physical, practical problems, data sets.
MLO2	Critically evaluate and apply skills and techniques from various mathematical and statistical areas towards the solution of one problem.
MLO3	Investigate and resolve issues that arise with open-ended and ill defined problems, making and refining assumptions as the work progresses.
MLO4	Use software (such as Maple, R, Python etc.) as problem-solving and result visualisation aids.
MLO5	Explain a problem and the mathematical and statistical approaches employed to solve the problem
MLO6	Critically review and communicate results effectively in the form of scientific graphs and visualisations.

Requisites

Module Content & Assessment

Assessment Breakdown	%
Other Assessment(s)	100.00%

Assessments

Other Assessment(s)

Assessment Type	Report	**% of Total Mark for Module**	100
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5,6
Assessment Threshold:	None	**Assessment Role**	Not yet determined
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
Written reports on the problems discussed in the classes, submitted either individually or as part of a team. Guidance on the format of the final report will be given to students at the outset of the case study depending upon the problem and the approach

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	39
Self Directed	161
Hours (up to 100 for 5 ECTS credits)	200.00

Recommended Reading List

Recommended Book Resources

Steven L. Brunton,J. Nathan Kutz. (2022), Data-Driven Science and Engineering, Cambridge University Press, [ISBN: 1009098489].

David R. Anderson,Dennis J. Sweeney,Thomas A. Williams,Jeffrey D. Camm,James J. Cochran. (2019), Statistics for Business & Economics, Cengage Learning, [ISBN: 1337901067].

David Collett. (2018), Modelling Binary Data, Chapman & Hall/CRC, [ISBN: 1138469564].

Gareth James,Daniela Witten,Trevor Hastie,Robert Tibshirani. (2021), An Introduction to Statistical Learning, Springer, [ISBN: 1071614177].

James T. McClave,P. George Benson,Terry Sincich. Statistics for Business and Economics, Global Edition, [ISBN: 1292227087].

Roxy Peck,Jay L. Devore. (2011), Statistics: The Exploration & Analysis of Data, Cengage Learning, [ISBN: 0840058012].

Alan B. Tayler. (2001), Mathematical Models in Applied Mechanics, Oxford University Press, [ISBN: 0198515596].

Peter Dalgaard. (2008), Introductory Statistics with R, Springer Science & Business Media, p.364, [ISBN: 978-0-387-79054-1].

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MATH 9973: Numerical Methods and Machine Learning for Differential Equations

Module Details

Module Code:	MATH 9973
Module Long Title:	Numerical Methods and Machine Learning for Differential Equations APPROVED
Banner Title:	Num and Machine Learning Methods for Diff Equation
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Sept 2022 (September 2022)
Language of Instruction:	English
ECTS Credits::	5
ISCED Code:	0541 - Mathematics
Current Coordinator::	JOHN BUTLER
Module Coordinators:	JOHN BUTLER (10 June 2022 to ---)
School Responsible:	School of Mathematics & Statistics
Campus:	City Campus
Module Overview	The aim of this module is to equip the learner with the knowledge necessary to implement computational techniques related to finite-difference methods and machine learning method for differential equations. During the first part of the module the learner will be introduced to the theory and practice of common techniques for the numerical integration of ordinary differential equations with initial conditions. . In the second part will of the module the learner will be introduced to the application of machine learning methods to estimate the solution of linear and non-linear ordinary differential equations. Software tools (python) will be used to implement the numerical and machine learning methods.
Indicative Syllabus	Numerical Analysis; Finite-differencing techniques; Stability analysis; Explicit Runge-Kutta methods, multi-step methods, shoot method, convergence, consistency and stability analysis, linear shooting methods. Machine Learning: Non-linear shooting method, Newton Raphson method; Gradient Descent; Loss functions; Norms, Forward and Back Propagation; Neural Network, The Universal Approximation Theorem for Neural Networks

Learning and Teaching Methods	This module is delivered through Blended Learning with a mix of synchronous and asynchronous online lectures and tutorials. Online delivery may use a flipped classroom approach, with pre-recorded material viewed in conjunction with synchronous sessions. There may be the occasional pre-planned in-person on-campus lecture/tutorial. Students will be required to undertake background reading and self-directed learning. The self-directed learning hours will be devoted to preparing for lectures, undertaking solutions to tutorials sheets, reflecting upon the lecture material, refining and deepening understanding and consolidating individual learning.

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Derive and apply a range of finite difference methods for solving differential equations for initial and boundary value problems
MLO2	Critically review the stability, consistency, and convergence properties of various numerical integration schemes for different practical problems.
MLO3	Interrogate the differences between various numerical methods for the integration of differential equations and evaluate the conditions under which they are an appropriate choice.
MLO4	Formulate and apply machine learning methods to approximate the solution of differential equations.
MLO5	Use numerical packages to solve differential equations and critically interpret and evaluate the results.

Requisites

Assessment Threshold	A minimum mark of 35% must be achieved on both components.

Module Content & Assessment

Assessment Breakdown	%
Formal Examination	60.00%
Other Assessment(s)	40.00%

Assessments

Formal Examination

Assessment Type	Written Examination	**% of Total Mark for Module**	60
Indicative Week	Week 14	**Learning Outcomes**	1,2,3,4
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
End of Semester Exam

Other Assessment(s)

Assessment Type	Case Study	**% of Total Mark for Module**	40
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
The Case Study will be to estimate solutions of differential equations using software (eg Python) by applying the Numerical and Machine Learning methods.

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	39
Self Directed	61
Hours (up to 100 for 5 ECTS credits)	100.00

Recommended Reading List

Recommended Book Resources

Steven L. Brunton,J. Nathan Kutz. (2019), Data-Driven Science and Engineering, Cambridge University Press, [ISBN: 1108422098].

A. Iserles. (2009), A First Course in the Numerical Analysis of Differential Equations, Cambridge University Press, [ISBN: 0521734908].

Supplementary Book Resources

Richard L. Burden,J. Douglas Faires. (1997), Numerical Analysis, Brooks Cole, [ISBN: 0534955320].

Steven H. Strogatz. (2014), Nonlinear Dynamics and Chaos, Westview Press, [ISBN: 0813349109].

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HEAD OF SCHOOL

MATH 9955: Project

Module Details

Module Code:	MATH 9955
Module Long Title:	Project HEAD OF SCHOOL
Banner Title:	Project
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Sept 2019 (September 2019)
Language of Instruction:	English
ECTS Credits::	25
ISCED Code:	0541 - Mathematics
Current Coordinator::	ROSSEN IVANOV
Module Coordinators:	ROSSEN IVANOV (09 January 2020 to ---)
School Responsible:	School of Mathematical Sciences (CC)
Campus:	City Campus
Module Overview	This module provides the learner with a platform for the advancement of their knowledge on a particular topic related to their studies on the programme and to develop their skills in the acquisition, assimilation, and communication of scientific knowledge.
Indicative Syllabus	**Written report** A written report will be prepared by the student in clear English in the learner's own words. Plagiarism guidelines for the programme are provided to the learner and must be strictly adhered to. The report will be between 15,000 and 25,000 words following a standard template provided by the School using the appropriate typesetting software introduced in the Research Skills module (e.g. Latex). Chapters, sections, equations, tables, figures, etc. will be numbered and cross-referenced. Equations must be consistently typeset (not included as images). All figures and tables must be properly attributed with copyright conditions identified and followed where necessary. Literature references will be managed by a suitable reference manager such as Zotero, BibTeX, and others. The report will consist of: cover page; abstract; table of contents; chapters following clearly demarcated themes with appropriate sections and subsections; conclusions; further work; references; appendices. The written report will be assessed on clarity, independence, level. **Presentation** The learner will make a 15 minute presentation of their work to the project assessment panel which may include the use of PowerPoint or pdf slides. During the presentation the learner will summarise their objectives, findings, and proposals for further investigations. Following the presentation, the learner may be required to answer questions from the panel on their work.
Learning and Teaching Methods	The primary objective of this module is to assist the learner in the development of skills required in the management of project work. The submission of a clear and concise scientific report coupled with a supplementary oral presentation of the work contained therein, aligns the assessed elements of the module are closely with best-practice outcomes for both academic and industry project work.

Module MATH 9955 - Project v1 (Year/Cycle:1 / Semester:Semester 3 / Delivery Type:Mandatory)

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Demonstrate techniques of scientific enquiry in a specialised area, to include literature review.
MLO2	Interpret and evaluate the literature in the context of a particular scientific topic.
MLO3	Reflect upon, organise, and effectively communicate key concepts from their work through interim and final written and oral presentation.
MLO4	Draw conclusions on review topic and critically assess findings of their work.
MLO5	Identify opportunities for further investigations in the field as opportunities for potential research topics.

Requisites		
Requisite Type	***Module Title***	***Type***
Pre Requisite	MATH 9976 v.1 Research Skills [Head of School]	Module

Assessment Threshold	35% treshold for the oral presentation component of the assessment.

Module Content & Assessment

Assessment Breakdown	%
Other Assessment(s)	100.00%

Derogations from the General Assessment Regulations

Compensation not permitted to or from this module.

Assessments

Other Assessment(s)

Assessment Type	Report	**% of Total Mark for Module**	60
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5
Assessment Threshold:	None	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
Written report

Assessment Type	Presentation	**% of Total Mark for Module**	40
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
Oral presentation

Module MATH 9955 - Project v1 (Year/Cycle:1 / Semester:Semester 3 / Delivery Type:Mandatory)

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	13
Self Directed	487
Hours (up to 100 for 5 ECTS credits)	500.00

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MATH 9976: Research Skills

Module Details

Module Code:	MATH 9976
Module Long Title:	Research Skills APPROVED
Banner Title:	Research Skills
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Jan 2023 (January 2023)
Language of Instruction:	English
ECTS Credits::	5
ISCED Code:	0541 - Mathematics
Current Coordinator::	ALBERTO CAIMO
Module Coordinators:	ALBERTO CAIMO (17 February 2023 to ---)
School Responsible:	School of Mathematics & Statistics
Campus:	City Campus
Module Overview	This module prepares students for the project or dissertation element of their programme. It is an essential prerequisite that describes the process of undertaking a substantial piece of academic writing including project planning and studies necessary skills such as typesetting in mathematics using appropriate software (e.g. Latex), referencing, and finding information using research databases and using the School style guide.
Learning and Teaching Methods	The module will be delivered through initial in-person sessions (typically two three-hour sessions) followed by self-directed learning through prepared worksheets and online guides. The module will require discussion with peers, peer feedback and the use of online resources.

Indicative Syllabus
1. Research sources 1.1) The use of the library and research databases
2. Project report, structure, layout and referencing 2.1) School style guide and referencing
3. Academic Writing 3.1) Academic writing and how to access guidance and support.

4. Type setting software system 4.1) How to typeset mathematics using appropriate software (e.g. Latex) and including figures and tables
5. Academic paper review 5.1) Guidance on critical review of an academic paper
6. Workplan 6.1) Preparation of workplan
7. Project proposal preparation 7.1) Prepare a proposal for a project or dissertation

Module MATH 9976 - Research Skills v1 (Year/Cycle:1 / Semester:Semester 3 / Delivery Type:Mandatory)

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Define research and the aims of research.
MLO2	Use research tools and databases to select, cite and summarise appropriate information.
MLO3	Write academically in accordance with the School style guide including appropriate referencing.
MLO4	Use typesetting software appropriate to mathematics and statistics.
MLO5	Critically review and evaluate a research publication.
MLO6	Formulate a proposal for a project or dissertation.
MLO7	Develop a realistic workplan.

Requisites

Module Content & Assessment

Assessment Breakdown	%
Other Assessment(s)	100.00%

Assessments

Other Assessment(s)

Assessment Type	Review	**% of Total Mark for Module**	100
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5,6,7
Assessment Threshold:	None	**Assessment Role**	Individual
Assessment Authenticity	Online	**Pass/Fail**	No

Assessment Description
Continuous Assessment will comprise the following: a review of an academic paper written formally in accordance with the School style guidelines using the typesetting software recommended; a proposal for their subsequent project/dissertation written in consultation with a prospective supervisor that includes: an indicative title, a description of the project/dissertation, a list of initial reading and sources, an outline workplan and timeline, evidence of research of information sources.

Module MATH 9976 - Research Skills v1 (Year/Cycle:1 / Semester:Semester 3 / Delivery Type:Mandatory)

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	6
Lecture	6
Self Directed	88
Hours (up to 100 for 5 ECTS credits)	100.00

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MATH 9975: Software Laboratory

Module Details

Module Code:	MATH 9975
Module Long Title:	Software Laboratory APPROVED
Banner Title:	Software Lab
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Jan 2022 (January 2022)
Language of Instruction:	English
ECTS Credits::	5
ISCED Code:	0541 - Mathematics
Current Coordinator::	JOHN BUTLER
Module Coordinators:	JOHN BUTLER (10 June 2022 to ---)
School Responsible:	School of Mathematics & Statistics
Campus:	City Campus
Module Overview	This module introduces students to the computer software and applications which will support their learning during the programme. The module does not assume any experience of programming or mathematical software packages and allows learners to become accustomed to the online learning platform of the University, the ICT resources of the School. The module will cover four different software types while will connect with the different modules across the programme: 1. Applied mathematics programming languages (e.g. Maple and Python) that links with modules such as Biomathematics, Methods for Applied Mathematics and Case Studies. 2. Statistical programming languages (e.g. R) that links with modules such as Case Studies, Modern Regression and Computational Statistics 3. Computational programming languages (e.g. Python) links with modules such as Case Studies and Numerical and Machine Learning Methods for Differential Equations. 4. Software packages for writing of reports (e.g. LaTeX and Rmarkdown) links with modules such as Case Studies, Research Skills and Global Citizenship. The module is practical and allows students to learn at their own pace.
	Initial introduction to the laboratory

Indicative Syllabus	• Introduction to the computer laboratory: accessing the lab and its computers; • Introduction to Bright Space; submitting assignments, feedback and getting help; • Introduction to software: e.g. R, Maple, Python, R and Latex; Self-directed learning using guided problems. Topics covered will support the software and learning requirements of the modules on the School's programme and typical topics may include: • Solving problems with Maple; integration, differentiation, differential equation solvers, visualising functions; • Solving problems with R; data input/output, visualisation, regression • Solving problems with Python; data input/output; numerical differentiation and integration, neural networks; • Disseminating solutions of problems with Latex and Rmarkdown.

Learning and Teaching Methods	The module will be delivered through laboratory sessions followed by self-directed learning through prepared workbooks and worksheets. Students will be required to support their learning through the use of online tutorials, support and help systems.

Module MATH 9975 - Software Laboratory v1 (Year/Cycle:1 / Semester:Semester 1 / Delivery Type:Mandatory)

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Develop learning and expertise in mathematical, statistical and computational software packages.
MLO2	Use a wide range of software packages to formulate and solve problems using mathematical and statistical techniques.
MLO3	Employ software packages for the design and creation of scientific graphs and data visualisations.
MLO4	Use software packages for disseminating mathematics and statistical problems and solutions.
MLO5	Access University online support, help systems, learning supports.

Requisites	
Assessment Threshold	35% threshold on each of the assignments contributing to Continuous Assessment

Module Content & Assessment

Assessment Breakdown	%
Other Assessment(s)	100.00%

Assessments

Other Assessment(s)			
Assessment Type	Practical Assignment	**% of Total Mark for Module**	100
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Online	**Pass/Fail**	No
Assessment Description Continuous Assessment 2 to 3 x practical assignments			

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	12
Self Directed	88
Hours (up to 100 for 5 ECTS credits)	100.00

Recommended Reading List

Recommended Book Resources

Peter Dalgaard. (2008), Introductory Statistics with R, Springer Science & Business Media, p.364, [ISBN: 978-0-387-79054-1].

David Collett. (2018), Modelling Binary Data, Chapman & Hall/CRC, [ISBN: 1138469564].

Steven L. Brunton,J. Nathan Kutz. (2022), Data-Driven Science and Engineering, Cambridge University Press, p.615, [ISBN: 1009098489].

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MATH 9954: Mathematical & Statistical Modelling with Case Studies

Module Details

Module Code:	MATH 9954
Module Long Title:	Mathematical & Statistical Modelling with Case Studies APPROVED
Banner Title:	Matths & Stats Modelling with Case Studies
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Sept 2022 (September 2022)
Language of Instruction:	English
ECTS Credits::	10
ISCED Code:	0541 - Mathematics
Current Coordinator::	DANA MACKEY
Module Coordinators:	• JOHN BUTLER (08 September 2022 to 09 September 2022) • DANA MACKEY (09 September 2022 to ---)
School Responsible:	School of Mathematics & Statistics
Campus:	City Campus
Module Overview	This modules expands on the use of mathematical and statistical modelling and simulation techniques applied to more complex problems. The projects undertaken in this module rely on more advanced mathematical topics and computational techniques. The module will be divided into 2 or 3 separate and independently assessed problems chosen from different application of applied statistical and mathematical methods to areas such as industrial heat and mass transfer, fluid mechanics, predator-prey modelling, neuroscience, computational finance, bioinformatics, environmental modelling, signal processing, statistical network analysis, survival analysis & frailty etc. Applying mathematical and statistical methods to real world case studies will highlight and stimulate discussions of ethical and sustainability issues when conducting research.
Indicative Syllabus	The underlying topics for the case studies will vary each year and will reflect current research and provide the widest possible perspective of the applications of mathematics and statistics in industry and other arena.

	Examples of case studies will be derived from ongoing research projects in the School, as well as reports from past Irish and European Study Groups with Industry. Typically, such problems will involve applying analytical, statistical and numerical methods to model and interpret industrial and scientific processes.
Learning and Teaching Methods	This module is delivered through Blended Learning with a mix of pre-planned in-person on-campus/ online discussion-based lectures and computer lab sessions. Students work on case studies as part of a team and on an individual basis. Substantial background reading and self-directed learning is required for this module, including the preparation and presentation of a written report for each case study. In addition to the Essential Reading list, other textbooks (or research articles) will be specified on an annual basis at the start of the module, depending on the topics to be covered.

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Formulate real world problems in statistical and mathematical terms.
MLO2	Source, read and critically evaluate literature on the underlying area.
MLO3	Identify, justify and use an appropriate methodology in the addressing task.
MLO4	Overcome real-world challenges, such as, insufficient data, very large data sets, open-ended and interdisciplinary problems, etc.
MLO5	Use more advanced computational aids for analysing models.
MLO6	Improve skills related to collaboration, scientific report writing and presentation.

Requisites

Module Content & Assessment

Assessment Breakdown	%
Other Assessment(s)	100.00%

Assessments

Other Assessment(s)

Assessment Type	Report	**% of Total Mark for Module**	100
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5,6
Assessment Threshold:	None	**Assessment Role**	Not yet determined
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
Written reports on the problems discussed in the classes, submitted either individually or as part of a team. Guidance on the format of the final report will be given to students at the outset of the case study depending upon the problem and the approach

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	39
Self Directed	161
Hours (up to 100 for 5 ECTS credits)	200.00

Recommended Reading List

Recommended Book Resources

Glenn R. Fulford,Philip Broadbridge. (2002), Industrial Mathematics, Cambridge University Press, [ISBN: 9780521001816].

Sam Howison. (2005), Practical Applied Mathematics, Cambridge University Press, [ISBN: 9780521603690].

David R. Anderson,Dennis J. Sweeney,Thomas A. Williams,Jeffrey D. Camm,James J. Cochran. (2019), Statistics for Business & Economics, Cengage Learning, [ISBN: 1337901067].

Alan B. Tayler. (2001), Mathematical Models in Applied Mechanics, Oxford University Press, [ISBN: 0198515596].

B. Barnes,G..R. Fulford. (2008), Mathematical Modelling with Case Studies, Chapman and Hall/CRC, [ISBN: 9781420083484].

Supplementary Book Resources

Steven L. Brunton,J. Nathan Kutz. (2022), Data-Driven Science and Engineering, Cambridge University Press, [ISBN: 1009098489].

James D. Murray. (2007), Mathematical Biology, Springer Science & Business Media, [ISBN: 978-0-387-22437-4].

James D. Murray. (2011), Mathematical Biology II, Springer, [ISBN: 0387952284].

James Keener,James Sneyd. (2010), Mathematical Physiology, Springer Science & Business Media, [ISBN: 978-0-387-75847-3].

Other Resources

Website, • The Oxford Centre for Industrial and Applied Mathematics (OCIAM) list of past Study Groups with Industry reports,
https://www.maths.ox.ac.uk/research/case -studies

APPROVED

MATH 9977: Computational Statistics

Module Details

Module Code:	MATH 9977
Module Long Title:	Computational Statistics APPROVED
Banner Title:	Computational Statistics
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Sept 2022 (September 2022)
Language of Instruction:	English
ECTS Credits::	5
ISCED Code:	0541 - Mathematics
Current Coordinator::	ALBERTO CAIMO
Module Coordinators:	ALBERTO CAIMO (10 June 2022 to ---)
School Responsible:	School of Mathematics & Statistics
Campus:	City Campus
Module Overview	The aim of this module is to introduce the student to a number of major topics in computational statistical methods. The student will gain experience of applying these methods to real datasets and experience of reporting their findings/conclusions. Statistical software (R or equivalent) will be heavily used.
Learning and Teaching Methods	This module is delivered through Blended Learning with a mix of synchronous and asynchronous online lectures and tutorials. Online delivery may use a flipped classroom approach, with pre-recorded material viewed in conjunction with synchronous sessions. There may be the occasional pre-planned in-person on-campus lecture/tutorial. Students will be required to undertake background reading and self-directed learning. The self-directed learning hours will be devoted to preparing for lectures, undertaking solutions to tutorials sheets, reflecting upon the lecture material, refining and deepening understanding and consolidating individual learning. A substantial emphasis will be placed on the use of software and students will be required to achieve a high level of competency in coding with a suitable data science language (e. g. R or equivalent).

Indicative Syllabus

1. Random Variable Generation
1.1) Uniform simulation. Inverse transform. General transformation methods.

2. Monte Carlo Simulation 2.1) Classical Monte Carlo integration. Accept-Reject methods. Importance sampling.
3. Markov Chain Monte Carlo (MCMC) 3.1) Markov chain processes, Metropolis–Hastings algorithms, Gibbs sampler, Convergence monitoring for MCMC algorithms.
4. Bootstrapping 4.1) Parametric and nonparametric bootstrap methods.

Module MATH 9977 - Computational Statistics v1 (Year/Cycle:1 / Semester:Semester 2 / Delivery Type:Elective)

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Interrogate and apply computational techniques in the context of classical and Bayesian estimation.
MLO2	Compute estimates for the model parameters using iterative algorithms.
MLO3	Critically evaluate the accuracy of the estimates obtained by simulation procedures.
MLO4	Design and implement computational techniques using advanced statistical tools (e.g., R).
MLO5	Devise and perform real data analyses and critically review, analyse and interpret the results.

Requisites	
Assessment Threshold	A minimum mark of 35% must be achieved on both components.

Module Content & Assessment

Assessment Breakdown	%
Other Assessment(s)	100.00%

Assessments

Other Assessment(s)

Assessment Type	Lab Test	**% of Total Mark for Module**	40
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No
Assessment Description Computer lab test			

Assessment Type	Data Interpretation/Analysis	**% of Total Mark for Module**	60
Indicative Week	See Student Handbook	**Learning Outcomes**	3,4,5
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No
Assessment Description Data analysis project			

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	39
Self Directed	61
Hours (up to 100 for 5 ECTS credits)	100.00

Recommended Reading List

Recommended Book Resources

Christian Robert,George Casella. (2010), Introducing Monte Carlo Methods with R, Springer Science & Business Media, [ISBN: 978-1-4419-1575-7].

Supplementary Book Resources

Jim Albert. (2009), Bayesian Computation with R, Springer, [ISBN: 978-0-387-92297-3].

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APPROVED

MATH 9952: Modern Regression Modelling

Module Details

Module Code:	MATH 9952
Module Long Title:	Modern Regression Modelling APPROVED
Banner Title:	MATH9952 Modern Regression Modelling
Version:	1
Indicative NFQ level:	Level 9
Valid From:	Jan 2023 (January 2023)
Language of Instruction:	English
ECTS Credits::	10
ISCED Code:	0542 - Statistics
Current Coordinator::	JOE CONDON
Module Coordinators:	JOE CONDON (15 June 2022 to ---)
School Responsible:	School of Mathematics & Statistics
Campus:	City Campus
Module Overview	This module introduces the student to a selection of major strands in modern regression modelling. An emphasis will be placed on model formulation, fitting algorithms and model interpretation. R software (or equivalent) will be used to fit models.
Learning and Teaching Methods	This module is delivered through Blended Learning with a mix of synchronous and asynchronous online lectures and tutorials. Online delivery may use a flipped classroom approach, with pre-recorded material viewed in conjunction with synchronous sessions. There may be the occasional pre-planned in-person on-campus lecture/tutorial. Students will be required to undertake background reading and self-directed learning. The self-directed learning hours will be devoted to preparing for lectures, undertaking solutions to tutorials sheets, reflecting upon the lecture material, refining and deepening understanding and consolidating individual learning. A substantial emphasis will be placed on the use of software and students will be required to achieve a high level of competency in coding with a suitable data science language (e. g. R or equivalent).

Indicative Syllabus

1. Exponential family regression models

1.1) Formulation, fitting and interpretations. Model building techniques.
2. Smoothing techniques in regression 2.1) Local regressions and splines (B-splines/P-splines). Regularization methods (e.g. lasso) to improve model prediction.
3. Classification using regressions 3.1) Measures of classifier accuracy; ROC, sensitivity, specificity and AUC.
4. Tree based methods 4.1) Classification and regression trees: applying regression trees, tree pruning. Bagging and random forests.

Learning Outcomes	
Upon successful completion of this module the learner will be able to	
#	
MLO1	Formulate exponential family regression models, e.g. binomial, poisson, gamma, multinomial.
MLO2	Fit, interpret and effectively report on generalised linear models and be able to fit these using the R software system (or equivalent).
MLO3	Apply model building methods in the GLM setting.
MLO4	Use smoothing techniques in regression settings: E.G. local regressions and spline based methods
MLO5	Apply regularization methods to improve model predictions in the GLM setting.
MLO6	Use regression models for classification (binary/multi-class problems).
MLO7	Measure the performance of regression based classifiers using specificity, sensitivity, ROC and AUC analysis.
MLO8	Use classification/regression tree methodologies to fit non-parametric classifiers/regressions.
MLO9	Use modern statistical software tools for fitting regression models to data such as R, Python, SAS (or equivalent).

Requisites	
Assessment Threshold	A minimum mark of 35% must be achieved in both components.

Module Content & Assessment

Assessment Breakdown	%
Formal Examination	50.00%
Other Assessment(s)	50.00%

Assessments

Formal Examination

Assessment Type	Written Examination	**% of Total Mark for Module**	50
Indicative Week	Week 15	**Learning Outcomes**	1,2,3,4,5,6,7,8
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
End of Semester Exam

Other Assessment(s)

Assessment Type	Report	**% of Total Mark for Module**	50
Indicative Week	See Student Handbook	**Learning Outcomes**	1,2,3,4,5,6,7,8,9
Assessment Threshold:	35	**Assessment Role**	Individual
Assessment Authenticity	Not Online	**Pass/Fail**	No

Assessment Description
Data analysis report.

Module Activity

Full Time hours per semester	
Activity Type	*Duration (Hours)*
Lecture	39
Self Directed	161
Hours (up to 100 for 5 ECTS credits)	200.00

Recommended Reading List

Recommended Book Resources

Draper W. R. & Smith H.. (2014), Applied Regression Analysis, Wiley., Third. Wiley.

David Collett. (2003), Modelling Binary Data, 2nd. Chapman and Hall/CRC.

Searle, S. R. and McCulloch, C.E .. (2001), Generalized, linear and mixed models., Wiley.

Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani. (2013), An Introduction to Statistical Learning: With Applications in R, Springer.

Trevor Hastie, Robert Tibshirani, Jerome Friedman. (2013), The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer.

Venables, W.N. and Ripley, B.D.. (2002), Modern Applied Statistics with S, Springer..

Supplementary Book Resources

Pawitan, Y. (2001), In All Likelihood: Statistical Modelling and Inference Using Likelihood.

Recommended Article/Paper Resources

Therneau, T.M. and Atkinson, E.J.. (2013), An Introduction to Recursive Partitioning Using the RPART Routines, Mayo Foundation. Technical Report 61., http://www.mayo.edu/hsr/techrpt/61.pdf