MODULE DESCRIPTOR 2021/22

CL329/CL331/CL332 Engineering Mathematics

Registrar: Dr John Douglas	**Taught To (Programme):** Civil Engineering / Civil and Environmental Engineering	
Other Lecturers Involved: Dr Matteo Pedrotti	**Credit Weighting:** 20	**Semester:** 1 (CL331) & 2 (CL332)
Assumed Pre-requisites: UG: MM115 Mathematics 1D & MM215 Mathematics 2D (or equivalent) PG: Maths at level 2	**Compulsory class**	**Academic Level:** NQF 5 Year 3

Class Format and Delivery (hours):

Lecture	Tutorial	Laboratory	Coursework	Project	Private Study	**Total**
44	44	0	0	0	112	200

Class Aim(s)

This class aims to give an introduction to statistics and probability (semester 1) and computer programming, in general, and Python, specifically (semester 2), and develop applications relevant to Civil and Environmental Engineering in these fields.

Learning Outcomes

On completion of the class the student is expected to be able to

LO1 Treat experimental/observational data statistically

LO2 Understand and use probabilistic models for civil and environmental engineering

LO3 Write and read basic scripts written in Python

LO4 Use Python scripts to analyse and visualize data

LO5 Create Python scripts to solve traditional mathematical and engineering problems

Syllabus

The class will teach the following (topics 1 and 2 in semester 1, CL331, and topics 3 and 4 in semester 2, CL332):

Topic 1: Statistics
- Presentation of statistical data
- Measurement of central tendency, dispersion and correlation
- Analyse and describe data using statistical descriptors
- Graphically display data
- Statistics within civil engineering

Topic 2: Probability
- Apply the basic rules of probability
- Identify the properties of discrete and continuous random variables
- Develop simple statistical models and make inferences using discrete probability distributions
- Assess whether data are normally distributed
- Use standard normal and Student's t distribution tables for statistical calculations
- Conduct hypothesis tests

Topic 3: Introduction to Python
- Python IDEs and Anaconda distribution
- Numbers

- Strings
- Variables
- Statements
- Data Structures
- Functions
- Input/output

Topic 4: Python as numerical tool
- Arrays and Matrices (Numpy library)
- Plots and data visualization (Matplotlib library)
- Optimization, linear algebra, integration, interpolation, special functions (Scipy library)
- Symbolic mathematic (Sympy library)

Assessment Criteria

For each of the Course Learning Outcomes the following criteria will be used to make judgements on student learning:

LO1 Treat experimental data statistically
C1 Calculate statistical descriptors of data
C2 Perform linear regression of data and analyse and present the results
C3 Perform log-linear regression of data and analyse and present the results

LO2 Understand and use probabilistic models for civil and environmental engineering
C1 Perform statistical hypothesis testing
C2 Calculate confidence intervals
C3 Calculate probabilities using fundamental rules and standard continuous and discrete distributions

LO3 Write and read basic scripts written in Python
C1 Create and run a script in Python
C2 Import, elaborate and output given datasets
C3 Use functions to accomplish specific tasks

LO4 Use Python scripts to analyse and visualize data
C1 Perform array and matrix operations on given data set
C2 Plot and visualize given data set
C3 Use Python numerical tools for optimization, interpolation problems

LO5 Create Python scripts to solve mathematical and engineering problems
C1 Create scripts to solve mathematical/engineering problems
C2 Use Python integration and differentiation numerical tools to solve mathematical/engineering problems

The standards set for each criterion per Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessments.

Principles of Assessment and Feedback (https://www.strath.ac.uk/staff/policies/academic/)

Please state briefly how these are incorporated in this module.

Principle 1. "Assessment and feedback practices promote effective student learning"

Exam-style tutorial questions and regular minitests are used throughout both semesters to illustrate civil and environmental engineering problems and reinforce skills needed to do well in the class test and exam. In both Semesters 1 and 2, students have 10 small assessments, a class test, and an examination per semester. Regular feedback allows them to gauge performance and close gaps between current and desired performance. Regular, two-hour tutorial sessions are built into the curriculum to support student learning. Both paper and computer-based assessments are used within semester 1, for some of which collaboration is allowed to encourage social learning. Computer-based assessments are used in semester 2.
Rapid feedback is provided on small assessments ahead of comprehensive class test and examination. In Semester 1, feedback is provided in real-time in an interactive fashion. Students are asked to solve problems of different level of complexity during the lecture and the lecture is tuned to the gaps shown by the students. In tutorials and revision sessions (before class tests and exams), students are asked to become teachers by explaining tasks to classmates.

Principle 2. "Assessment and feedback practices are appropriate, fair, and transparent"

All of the assessments are based on examples from civil and environmental engineering or related disciplines. The tasks aim to test skills required in civil and environmental engineering practice using tools (e.g. software packages) that are used in this context. The mark scheme for each assessment is defined before the students

undertake the assessment and this marking scheme is followed rigorously based solely on the students' submissions.

Principle 3. "Assessment and feedback practices are clearly communicated to students and staff"

The grading scheme used for each assessment is made clear to the students at the beginning of each semester as well as before each individual assessment (e.g. via the front page of the exam paper). The timing of each assessment is also stated at the beginning of the semester and the students are reminded on this throughout the semester. The marks available for each part of the assessments are clearly stated. Past papers from previous years are provided to the students for practice and to understand the assessment practices.

Principle 4. "Assessment and feedback practices are continuously reviewed"

Lecturers engage regularly with students and class reps about how the semester is going, including, but not limited to, assessment. We make use of mid-term questionnaires and discussion with class reps to obtain feedback from students and possibly adjust teaching approach. In addition, feedback provided by the students in end-of-semester questionnaires are carefully studied with a view to modifying the assessment and feedback practices of the coming year, in addition to the experience gained by the lecturer when teaching the course.

Recommended Reading

- Applied statistics for civil and environmental engineers, N. T. Kottegoda, R. Rosso, Dawsonera, 2nd ed. Oxford : Blackwell 2008
- Facts from Figures, M. J. Moroney, 3rd rev.ed., Penguin books 1956
- Introduction to probability and statistics for engineers and scientists, S. R. Ross, 5th ed., Elsevier, 2014
- Introduction to probability and statistics, W. Mendenhall, Edition 15, metric version, Cengage, 2020
- Advanced Guide to Python 3 Programming. Hunt, John. Cham: Springer International Publishing AG 2019
- Python Programming Fundamentals. Lee, Kent D Mackie, Ian (Editor). 2nd ed. 2014 London: Springer London 2014. Undergraduate Topics in Computer Science
- A Beginners Guide to Python 3 Programming. Hunt, John Mackie, Ian (Editor) ; Abramsky, Samson (Editor) ; Hankin, Chris (Editor) ; Hinchey, Mike (Editor) ; Kozen, Dexter C (Editor) ; Pitts, Andrew (Editor) ; Riis Nielson, Hanne (Editor) ; Skiena, Steven S (Editor) ; Stewart, Iain (Editor). Cham: Springer International Publishing 2019. Undergraduate Topics in Computer Science
- Elementary Mechanics Using Python: A Modern Course Combining Analytical and Numerical Techniques. Malthe-Sørenssen, Anders Ashby, Neil (Editor); Brantley, William (Editor) ; Fowler, Michael (Editor) ; Hjorth-Jensen, Morten (Editor) ; Inglis, Michael (Editor) ; Klose, Heinz (Editor) ; Sherif, Helmy (Editor). 2015 Cham: Springer International Publishing 2015. Undergraduate Lecture Notes in Physics
- The Python Workbook: A Brief Introduction with Exercises and Solutions. Stephenson, Ben 2014 Cham: Springer International Publishing 2014

PLEASE NOTE:
Students need to gain a summative mark of 40% to pass the module. Students who fail the module at the first attempt will be re-examined during the August diet. This re-examination will consist entirely of exam.

Resit Arrangements

Examination is 3 hours in length (1.5h for semester 1's material and 1.5h for semester 2's material). Semester 1's part requires use of a PC (Excel and Minitab) and access to Myplace. Semester 2's part requires use of a PC (Anaconda) and access to Myplace.

Approved

Programme Director Signature:
Date of Last Modifications: 6th August 2021

Assessment and Feedback Schedule

Class Code	CL329	Class Title	Engineering Mathematics

Brief Description of Assessment

Individual exams, class tests (T) and mini tests (MT) in both semesters. In semester 1 the MTs are online and require a mark of 80% or more to obtain the 1% credit towards the final grade (repeat attempts may be made within the time-limit). In semester 2 the MTs are online assignments and a mark of 80% or more to obtain the 1% credit towards the final grade (students will work against a known solution and will be able to submit only when they think they accomplished the task).
All assessments require use of a PC (Excel and Minitab in semester 1 and Anaconda in semester 2) and access to Myplace. In semester 1, real-time automatic feedback is provided on these MTs during the assessment. In addition, at the following lecture some general feedback is given. General feedback on the class test is also provided during a subsequent lecture. Worked solutions are provided for both the class test and exam following release of the marks.

Indicate in the tables below the Hand-Out (H), Submission (S) and Feedback (F) dates for each lab report/coursework/project and the timing of each Exam/Class Test (E), (T). Include duration of exam in brackets (e.g. E (2)).

Semester 1

Assessment type (& title)	LOs	Weight (%)	Individual / Group	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
MT	LO1	5	Individual but collaboration allowed	E (2)	E (2)	E (2)	E (2)	E (2)							
MT	LO2	5	Individual but collaboration allowed						E (2)		E (2)	E (2)	E (2)	E (2)	
Class Test	LO1, LO2	15	Individual							T (1.5)		F (T)			
Exam	LO1, LO2	25	Individual												E (2)

Semester 2

Assessment type (& title)	LOs	Weight (%)	Individual / Group	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
MT	LO3	5	Individual but collaboration allowed			S	F (S)	S	F (S)						
MT	LO4, LO5	5	Individual but collaboration allowed								S	F (S)	S	F (S)	
Class Test	LO3	15	Individual							T (2)		F (T)			
Exam	LO4, LO5	25	Individual												E (2)

.Mapping Module Learning Outcomes to AHEP

Module Learning Outcome	**Engineering Council AHEP competencies: Knowledge, Understanding and Ability**
LO1 Treat experimental/observational data statistically	**Science and mathematics** • A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies • Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in their engineering discipline and to enable them to apply a range of mathematical and statistical methods, tools and notations proficiently and critically in the analysis and solution of engineering problems **Engineering analysis** • Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and to implement appropriate action **Additional general skills** • Apply their skills in problem solving, communication, working with others, information retrieval and the effective use of general IT facilities
LO2 Understand and use probabilistic models for civil and environmental engineering	**Science and mathematics** • A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies • Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in their engineering discipline and to enable them to apply a range of mathematical and statistical methods, tools and notations proficiently and critically in the analysis and solution of engineering problems **Engineering analysis** • Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and to implement appropriate action **Economic, legal, social, ethical and environmental context** • Knowledge and understanding of risk issues, including health & safety, environmental and commercial risk, risk assessment and risk management techniques and an ability to evaluate commercial risk **Engineering practice** • Ability to work with technical uncertainty

LO3 Write and read basic scripts written in Python	**Science and mathematics** • A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies • Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in their engineering discipline and to enable them to apply a range of mathematical and statistical methods, tools and notations proficiently and critically in the analysis and solution of engineering problems • Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline and the ability to evaluate them critically and to apply them effectively • Awareness of developing technologies related to own specialisation • A comprehensive knowledge and understanding of mathematical and computational models relevant to the engineering discipline, and an appreciation of their limitations • Understanding of concepts from a range of areas, including some outside engineering, and the ability to evaluate them critically and to apply them effectively in engineering projects **Engineering analysis** • Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and to implement appropriate action • Ability to extract and evaluate pertinent data and to apply engineering analysis techniques in the solution of unfamiliar problems **Design** • Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem including production, operation, maintenance and disposal **Additional general skills** • Apply their skills in problem solving, communication, working with others, information retrieval and the effective use of general IT facilities
LO4 Use Python scripts to analyse and visualize data	**Science and mathematics** • A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies • Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in their engineering discipline and to enable them to apply

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LO5 Create Python scripts to solve traditional mathematical and engineering problems	**Science and mathematics** • A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies • Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in their engineering discipline and to enable them to apply a range of mathematical and statistical methods, tools and notations proficiently and critically in the analysis and solution of engineering problems • Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline and the ability to evaluate them critically and to apply them effectively • Awareness of developing technologies related to own specialisation • A comprehensive knowledge and understanding of mathematical and computational models relevant to the engineering discipline, and an appreciation of their limitations

	• Understanding of concepts from a range of areas, including some outside engineering, and the ability to evaluate them critically and to apply them effectively in engineering projects **Engineering analysis** • Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and to implement appropriate action • Ability to extract and evaluate pertinent data and to apply engineering analysis techniques in the solution of unfamiliar problems **Design** • Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem including production, operation, maintenance and disposal **Additional general skills** • Apply their skills in problem solving, communication, working with others, information retrieval and the effective use of general IT facilities

JBM Programme Threads

Thread	Primary	Secondary	Contributory
Design		Importance of assumptions is emphasised in defining engineering problems	
Health, Safety & Risk Assessment		Examples in semester 1 (e.g. accident rates). Assessing risk using probabilities.	
Sustainability			Examples in semesters 1 and 2
Maths for Engineers	Course is focussed on teaching mathematical skills used by engineers		
Industrial Engagement			Examples in semesters 1 and 2
Digital Technologies	Semester 2 is focussed on teaching programming skills for engineers (Python)	Use of MS Excel and Minitab in semester 1	