MODULE DESCRIPTION FORM

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

ME209 Mathematical Modelling and Analysis

Module Registrar: Dr E Minisci edmondo.minisci@strath.ac.uk	**Taught To (Course): Cohorts for whom class is compulsory**	
Other Lecturers Involved:	**Credit Weighting: 20 (ECTS 10)**	**Semester: 1 and 2**
Compulsory class	**Academic Level: 2**	**Suitable for Exchange: Y**

Required prerequisites

Note: It is the responsibility of ALL students to ensure that they satisfy the prerequisite knowledge for this module BEFORE adding as part of curriculum selection. If unsure, please contact the Module Registrar or discuss with your Programme/Year Adviser of Studies.

Good programming skills:
Knowledge of basic programming principles:
- manipulation of scalar, vectors and matrices variables.
- use of operators, expressions and statements (including conditional statements).
- algorithms, structured programming logic and flow diagrams.
- computer arithmetic and errors.

Fundamentals of programming in MATLAB:
- data types; input and output; functions and structures; parameters and variables; memory allocation.

Good mathematical skills:
Linear algebra, vectors & matrices.
Be able to factorise quadratic functions.
Be able to manipulate equations and the change the subject of more complex equations.
Be able to work confidently with logarithms and exponentials.
Be able to integrate and differentiate trigonometric functions, logarithms, and exponentials.
Apply the chain rule, product rule and quotient rule of differentiation.
Carry out integration by substitution and by parts.
Basics of Probability and Statistics, and in particular:

- Data presentation: frequency tables, histograms, mean, standard deviations, quartiles.
- Mean and expected value, mean, variance. Sampling distributions, estimation, confidence intervals, t-distribution.
- Estimation and hypothesis testing. Sampling, standard errors, confidence limits.
- Probability theory and models. Random variables and probability distributions. Elementary distributions: Properties of distribution, central limit theorem.

Numerical Methods:
Solution of systems of linear equations; differentiation and integration.

Engineering Mechanics:
Have understood and overcome any misconceptions about basic concepts in physics (force, energy, work etc).
- Perceive, or resolve, contradictions involving their preconceptions about mechanics
- Organise the basic ideas of mechanics in a form suitable for problem solving
- Apply basic principles in mechanics to realistic engineering situations
- Solve realistic engineering problems

Module Format and Delivery (HOURS i.e., 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	**Total**
41		20					25	114	200

Educational Aim

This module aims to develop the general approach to the solution of engineering problems and involves mathematical modelling, numerical methods and the application of computer software. A wide range of engineering topics is presented and includes problems in structures, dynamics, fluids and heat transfer to emphasise the general applicability of the solution processes.

The integration of mathematical techniques and the use of the computer as an essential tool in the modelling, simulation and solution of problems in engineering is an important objective of the class. It is also designed to demonstrate the power of mathematical methods to the formulation and manipulation of equations to represent complex engineering systems.

Students will be required to dig deeper into statistical methods that are particularly relevant to engineering practices. The practical aspect of the statistical knowledge has to be developed within a computational environment, to allow the estimation, simulation, and assessment of statistical models to be carried out. This will be developed further by introducing context from industrial engineering applications of statistical methods.

Learning Outcomes

On completion of the module the student is expected to:

Engineering Analysis (Semester 1)

LO1 understand the use of mathematical methods and their role in formulating equations to represent a variety of problems in engineering and be able to apply mathematical methods for the formulation of ordinary differential equations and linear equation systems.
LO2 be able to choose and apply a variety of numerical methods to solve ordinary differential equations, simultaneous equations, and to numerically differentiate and integrate data and equations.
LO3 be able to model simple problems involving dynamic simulation techniques and apply mathematical software such as MATLAB to the solution of engineering problems.

Engineering Analysis (Semester 2)

LO4 have a fundamental understanding of statistical concepts and techniques, and knowledge of computational techniques for the estimation, simulation, and assessment of statistical models.
LO5 be able to apply advanced statistical methods to analyse complex engineering data associated to engineering problems, with a particular focus on quality control, and process and product improvement.

Syllabus

The module will teach the following:

Engineering Analysis (Semester 1)

Data regression: Linear and nonlinear data regression analysis for interpreting data and curve fitting.

Concepts of mathematical modelling: case studies in formulation of equation systems and differential systems for structural, dynamic, fluid and thermal problems.

Numerical methods: Gaussian elimination, LU decomposition, Cramer's Rule, Inverse Method. Solution of simultaneous linear and nonlinear equations; Jacobi and Gauss Seidel Iteration method; Newton Raphson method; Secant Method; Numerical differentiation and integration, applications to multiple integrals, numerical quadrature, evaluation of areas.

Numerical Solution of ordinary differential equations: classification of solution methods with engineering applications in dynamics, thermodynamics, fluid mechanics, solid and structural mechanics using computer-aided engineering techniques. Numerical solution of ordinary differential equations, initial value problems, predictor corrector methods. Runge-Kutta methods. Multi-step methods.

Numerical Solution of integrals: methods to solve single and multiple integrals, trapezoidal method, Simpson's rule.

Software applications: Use of MATLAB.

Engineering Analysis (Semester 2)

Advanced Data Analysis and Interpretation: Apply advanced statistical methods to analyse and interpret engineering data. Use various techniques to model and analyse time-to-event (survival) data, reliability data, and other types of engineering data.

Experimental Design and Analysis of Variance (ANOVA): Design experiments effectively to answer engineering questions. Basis of ANOVA and its application to analyse the effects of different factors on a response.

Regression Analysis: Perform and interpret multivariate linear regression analyses. Use regression analysis to build predictive models for engineering applications.

Non-parametric Statistics: Understand and apply non-parametric statistical methods when data do not meet normal distribution assumptions.

Statistical Process Control (SPC): Recall of Hypothesis Testing. Understand the principles of SPC and its role in quality improvement. Construct and interpret control charts for variables and attributes. Compute and interpret process capability indices. Use process capability analysis to assess the ability of a process to meet specifications.

Acceptance Sampling: Understand the concepts of acceptance sampling. Design and analyse acceptance sampling plans for attributes and variables.

Quality Control and Improvement: Understand the principles of Six Sigma and its role in quality improvement. Apply basic Six Sigma tools to improve process quality in engineering contexts. Critical thinking in quality control.

Software applications: Use of MATLAB.

Assessment of Learning Outcomes

Criteria

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

LO1
C1 How students understand the use of mathematical methods and their role in formulating equations to represent a variety of problems in engineering, and how to apply mathematical methods for the formulation of ordinary differential equations and linear equation systems (Coursework 1 , Online Time Constrained Quizzes 1 and 2).

LO2
C1 How to choose and apply a variety of numerical methods to solve ordinary differential equations, simultaneous equations, and to numerically integrate equations (Online Time Constrained Quizzes 1 and 2)

LO3
C1 how to model simple problems involving dynamic simulation techniques and apply mathematical software to the solution of engineering problems (Coursework 1).

LO4
C1 How students understand the use of statistical concepts and techniques, and use computational techniques for the estimation, simulation, and assessment of statistical models. (Coursework 2 and Online Time Constrained Quiz 3)

LO5
C1 How to apply advanced statistical methods to analyse complex engineering data associated to engineering problems, with a particular focus on process and product quality control and improvement. (Coursework 2 and Online Time Constrained Quiz 3)

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

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

- In order to promote student engagement and self-regulation in learning, the Principles of Assessment and Feedback are adapted to suit current disciplinary context. The assessment method adopted in this module includes examination, mid-term tests and coursework assignments, with proper feedback for student learning.
- Regular formative feedback will be provided by verbal discussion on an individual or group basis of work during the tutorials timetabled for the classes.
- Formal, written feedback will be provided by the return of the assessment mark to students. For the assessment of coursework reports, both summative assessment and formative feedback will be provided. The summative assessment will positively influence how students interact with formative assessment and feedback.

Assessment Method(s) Including Percentage Breakdown and Duration of Exams *(individual weightings)*

Examination				Coursework		Practical		Project	
Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***	Number	***Weighting***
				2 (see below) 3 Online Time Constrained Quizzes (see below)	50% 50%				
*				*LO1, LO2, LO3, LO4, LO5		*		*	

* ***L/Os:*** *Indicate which Learning Outcomes (L01, L02, etc) are to be assessed by exam/coursework/practical/project as required.*

Engineering Analysis Semester 1 - 50% combined assessment (consisting of 30% for two online time constrained quizzes in week 6 and week 11 and 20% for one coursework assignment assigned in week 10).

Engineering Analysis Semester 2 - 50% combined assessment (consisting of 20% for one online time constrained quiz in week 8, and 30% for one coursework assignment assigned in week 8).

Coursework / Submissions deadlines (*academic weeks*):

Time Constrained Quizzes - semester 1: week 6 and week 11; semester 2: week 8

Coursework – semeser2: week 1 and week 11

Resit Assessment Procedures:

Submission of ^^resit coursework (covering whole module content) prior to commencement of July/August exam diet.

^^Students must contact the module Registrar for details as soon as results confirm that a resit is required.

PLEASE NOTE:
Students must gain a summative mark of 40% to pass the module. Students who fail the module at the first attempt will be re-assessed prior to the July/August exam diet. This re-assessment will consist entirely of coursework. No marks from any previous attempts will be transferred to a new resit attempt.

Recommended Reading

*****Purchase recommended **Highly recommended reading *For reference**

Engineering Analysis - Notes are provided on Myplace

- Numerical Methods for Engineers" by Chapra and Canale, ISBN 0-07-100412-2
- Edward B. Magrab, "Engineering Statistics – An introduction", Springer, 2022 (https://link.springer.com/book/10.1007/978-3-031-05010-7)
- Montgomery, D.C., Runger, G.C., Applied Statistics and Probability for Engineers (5th Ed.), John Wiley and Sons, 2011. (or any other edition)
- Montgomery, D.C., Introduction to Statistical Quality Control (7th Ed.), John Wiley and Sons, 2013. (or any other edition)

Additional Student Feedback
(Please specify details of when additional feedback will be provided)

Date	Time	Room No
Weekly tutorial	TBC	Check timetable webpages for details

Session: 2024/25

Approved:

Programme Lead/Director Signature: Dr G Houston-Scott

Date of Last Modifications: 02/08/2024

(MAE template updated July 2024)

MODULE TIMETABLE

Module Code:	**ME209**	**Module Title:**	**Mathematical Modelling and Analysis**

Brief Description of Assessment:

Engineering Analysis Semester 1 – 50% combined assessment (consisting of 30% for two 1-hour online time constrained quizzes and 20% for one coursework assignment).

Semester 2 – 50% combined assessment (20% for one 1h online time constrained quiz, and 30% for one coursework assignment).

For both coursework assignments, the students should submit a professional standard report and the MATLAB code as requested and further details are provided on Myplace.

Assessment Timing

Indicated on the table below are the start/submission dates for each assignment/project and the timing of each exam/assessment.

Please note: Timings could change during unforeseen periods of disruption; this should only be used as a guide.

Semester One	W&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Online Test Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Set	Online Test	Choose an item. Choose an item.

Semester Two	C&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Course work Submit	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Set Online Test	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Submit	Choose an item. Choose an item.