UNIVERSITY of BRADFORD

Module Descriptor

Module Details	
Module Title:	Modelling and Optimisation
Module Code:	ENM7005-B
Academic Year:	2019-20
Credit Rating:	20
School:	Engineering and Informatics (Faculty-wide)
Subject Area:	Engineering Mathematics
FHEQ Level:	FHEQ Level 7 (Masters)
Pre-requisites:	
Co-requisites:	

Contact Hours

Type	Hours
Lectures	28
Tutorials	16
Laboratory	4
Directed Study	152

Availability

Occurrence	Location / Period
BDA	University of Bradford / Semester 1 (Sep - Jan)

Module Aims

To establish working knowledge of the role and importance of modelling and optimisation within modern (science and) engineering practice, with evidence and practice to demonstrate that it is just one component of an integrated tool kit that includes analytical, numerical, simulation, and statistical methods for addressing, evaluating, and improving multiple solutions to science and engineering-based problems.

Outline Syllabus

MODELLING

Building empirical and surrogate models through linear multiple regression analysis; design of engineering experiments; introduction to response surface methodology;

Designed of Experiments methodology, including factorial experiments, fractional factorials, custom and optimal designs;

Statistical models based on physical experiments; analysis of residuals; Planning and managing an experiment in practice;

Success criteria for a prediction equation; selecting terms in a polynomial model; underfitting and overfitting model validation;

Dealing with background variation. Using a prediction equation with noise factors, including Monte Carlo methods;

Computer based experiments; space-filling / Latin Hypercube DoEs, nonlinear interpolation models including Neural Networks, Radial Basis Functions and Gaussian Kriging.

Engineering case studies – both physical experiments and computer based experiments.

OPTIMISATION

Formulation: terminology, translating descriptive engineering design problems into mathematical optimisation problems, constrained and unconstrained problems, formulating constraints imposed on engineering system behaviour, global and local optima.

Numerical optimisation: one-dimension, deterministic methods. Constrained problems (Kuhn-Tucker optimality, Lagrange multipliers, Penalty functions, SUMT).

Bio-inspired techniques.

Multi-modal optimisation.

Multi-objective problems: Pareto-optimal solutions, numerical approaches (discrete and continuous criteria).

Multidisciplinary optimisation.

Learning Outcomes	
1	Demonstrate a critical understanding of design of experiments and response surface methodology in theory and practice as applied to engineering problem-solving, problem prevention and product development.
2	a. Plan and run statistically based experiments appropriate to a wide variety of engineering scenarios. b. Fit and validate response surface models to the resulting data. c. Use RSMs to understand the impact of variation on system performance.
3	Demonstrate advanced statistical experimentation skills, use of specialised packages for DoE analysis, communicate effectively in a project team and contribute to teamwork facilitation.
4	Knowledge & Understanding: On successful completion of this module you will be able to critically evaluate the fundamental concepts of design optimisation and select,

	implement and assess a range of appropriate optimisation techniques;
5	Subject-Specific Skills: On successful completion of this module you will be able to formulate and solve an optimisation problem related to engineering design;
6	Personal Transferable Skills: On successful completion of this module you will be able to collate and manage data, and apply scientific method, IT skills and complex systematic problem-solving strategies.

Learning, Teaching and Assessment Strategy

This module will be delivered through a combination of formal presentations and hands-on case-studies. The learning materials (both lecture notes and case study) use a coherent problem-based approach, introducing statistical ideas and tools for the planning and analysis of designed experiments in the context of a range of Engineering scenarios.

Knowledge (theory, calculation, implementation methodology, critical analysis, application) is disseminated in lectures, case studies, and directed study, with practice and a variety of engineering applications and context being established in exercise classes. Application of skills are taught and practiced in computer laboratory sessions.

Oral feedback is given during computer laboratory sessions and exercise classes. Written feedback (generic and individual) is provided via returned in-session assessment.

Directed study provides students with the opportunity to undertake guided reading and to develop their own portfolio of learning to enhance transferable skills and knowledge relating to evaluation of own role and subject provision.

There will be regular tutorial sessions, coursework support slots, exam revision question sessions, a summary session, and to-be-arranged revision sessions prior to the examination. A formative exam will be provided.

Assessment combines an individual report on the application of DoE and RSM methodology to an Engineering problem with a final closed-book examination to assess the wider learning outcomes of the module. Engineering application and methodological skills are assessed in a problem-solving and report-based coursework (supports written feedback). Expected length of the report is about 2,500 words, including reflection on learning and on the broader context of the application of advanced statistical tools and methods to real world engineering problems.

This module satisfies the below Learning Outcomes as specified by the Accreditation of Higher Education Programmes: Third Edition (AHEP3) as published by The Engineering Council in-line with the UK Standard for Professional Engineering Competence (UK-SPEC). These outcomes specify six key areas of learning: Science and Mathematics (SM), Engineering Analysis (EA), Design (D), Economic, Legal, Social, Ethical and Environmental Context (EL), Engineering Practice (P) and Additional General Skills (G).
SM1m, SM2m, SM3m, SM5m, SM6m, EA1m, EA2, EA3m, EA6m, EL4, P3, P4, P9m, G1, G4, SM7M, SM8M, EA6M, EA7M.
Further details of these learning outcomes can be found at https://www.engc.org.uk/.

Mode of Assessment

Type	Method	Description	Length	Weighting

Summative	Examination - closed book	Answer 1 compulsory and choice of 2 from 4 questions covering syllabus areas not assessed in coursework	2 hours	50%
Summative	Coursework	2,500 word individual report on the application of DoE, RSM and optimisation methodology to an engineering problem set in context:formulation, numerical solution, interpretation.	-2500 words	50%
Formative	Classroom test	Mock examination during class hours	80 minutes	%

Reading List
To access the reading list for this module, please visit https://bradford.rl.talis.com/index.html.

Please note:

This module descriptor has been published in advance of the academic year to which it applies. Every effort has been made to ensure that the information is accurate at the time of publication, but minor changes may occur given the interval between publishing and commencement of teaching. Upon commencement of the module, students will receive a handbook with further detail about the module and any changes will be discussed and/or communicated at this point.