UNIVERSITY of BRADFORD

Module Descriptor

Module Details	
Module Title	Modelling and Optimisation
Module Code	ENM7005-B
Academic Year	2021/2
Credits	20
School	Department of Mechanical and Energy Systems Engineering
FHEQ Level	FHEQ Level 7

Contact Hours	
Type	Hours
Lectures	24
Tutorials	12
Laboratories	4
Directed Study	160

Availability	
Occurrence	Location / Period
BDA	University of Bradford / Semester 1

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 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; under-fitting 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 (physical 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). Bioinspired techniques. Multi-modal optimisation. Multi-objective problems: Pareto-optimal solutions, numerical approaches (discrete and continuous criteria). Multidisciplinary optimisation.

Learning Outcomes

Outcome Number	Description
01	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.
02	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.
03	Demonstrate advanced statistical experimentation skills, use of specialised packages for DoE analysis, communicate effectively in a project team and contribute to teamwork facilitation
04	Critically evaluate the fundamental concepts of design optimisation and select, implement and assess a range of appropriate optimisation techniques.
05	Formulate and solve an optimisation problem related to engineering design.
06	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. Interactive sessions will encourage individuals to bring experiences and ideas to the table with peer learning encouraged.

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. Peer support is encouraged to build strong cohort identity based on diverse and equally valued backgrounds.

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

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 and a set of extended applications-based problems to test selection, implementation, and interpretation of optimisation methods. 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.

Mode of Assessment

Type	Method	Description	Weighting
Summative	Coursework - Written	Answer extended applications questions covering syallbus areas on optimisation	50%
Summative	Coursework - Written	2,500 word individual report on the application of DoE, RSM and optimisation methodology to an engineering problem set	50%
Formative	Coursework - Written	Answer all questions assessments and individual questions at appropriate points in module delivery with subsequent live worked solutions for self-marking and gap analysis. Full solutions uploaded.	N/A

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.
