UNIVERSITY of BRADFORD

Module Descriptor

Modelling and Optimisation

Module Code:	ENM7005-B
Academic Year:	2018-19
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	30
Tutorials	16
Laboratory	2
Directed Study	152

Availability Periods

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

Module Aims

To establish an appreciation for the role of optimisation within modern (science and) engineering practice and to provide evidence that optimisation is just one component of an integrated tool kit (that includes analytical, simulation, and statistical methods met at earlier FHEQs) for addressing, evaluating, and improving multiple solutions to science and engineering-based problems.

Outline Syllabus

MODELLING

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

Designed experiments and empirical transfer functions, including least squares fitting. Specific designs including two-level fractional factorials, Central Composite, custom designs for special situations

Statistical models for hardware data; analysis of residuals

Success criteria for a prediction equation; selecting terms in a polynomial model

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

Planning and managing an experiment in practice

OPTIMISATION

Formulation: translating descriptive (semantic) engineering design problems into mathematical optimisation problems, design variables, objective function, linear/nonlinear mathematical programming, constrained and unconstrained problems, formulating constraints imposed on engineering system behaviour. Global/local optima.

Kuhn-Tucker optimality conditions. Classification of optimisation problems. Numerical optimisation: iterative techniques (local/global 1D, unconstrained multi-parameter, general constrained). Penalty function methods, random search, bio-inspired techniques.

Multi-objective problems: Pareto-optimal solutions.

Approximation techniques: global and local approximations used with numerical analysis of an engineering system.

Multidisciplinary optimisation: AAO, MDF, IDF, CO, ATC.

Module Learning Outcomes

On successful completion of this module, students will be able to...

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 empirical transfer functions to the resulting data. c. Use transfer functions 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 (coursework / SEM 1).

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.
"Modelling" assessment is via an individual report on the application of DoE and RSM methodology to an Engineering problem. 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.

"Optimisation" assessment reflects content and summative requirements: Engineering application and methodological skills are assessed in a problem-solving and report-based coursework (supports written feedback); The wider learning outcomes of the module are assessed in a final closed-book examination.

Coursework reflects a need to demonstrate competency in formulating a design optimisation problem from a ‘problem description’, selecting and (correctly) applying a range of numerical optimisation approaches, and interpreting the results and limitations observed. Coursework is distributed in week 6, with a clarification Q&A session during week 7. The coursework submission deadline is week 13 of Semester 1 (details of the submission process will be advised nearer to the time).

The closed book examination addresses implementation and understanding of numerical optimisation methods.

Mode of Assessment

Type	Method	Description	Length	Weighting	Final Assess'
Summative	Examination - closed book	Answer 2 compulsory and choice of 1 from 3 questions covering syllabus areas not assessed in coursework	1.5 hours	50%	Yes
Referral	Examination - closed book	Answer 2 compulsory and choice of 2 from 3 questions covering full syllabus	2 hours	100%	Yes
Summative	Coursework	2,500 word inidividual report on the application of DoE, RSM and optimisation methodology to an engineering problem set in context:formulation, numerical solution, interpretation.	-2500 words	50%	No
Formative	Classroom test	Mock examination during class hours	1.5 hours	%	No

Legacy Code (if applicable)

Reading List

To view Reading List, please go to **rebus:list**.