ST305-15 Designed Experiments

22/23

Department
Statistics
Level
Undergraduate Level 3
Module leader
Samuel Touchard
Credit value
15
Module duration
10 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module runs in Term 2 and aims to give students a sound understanding of experimental design, both theoretical and practical. The course will explore the method of analysis of variance and show how it is structurally linked to particular types of design. The combinatoric properties of designs will be explored, and the impact of computers on classical design considered. Some exploration of the matrix theory of design will also be undertaken.

Pre-requisites:
Statistics Students: ST218 Mathematical Statistics A AND ST219 Mathematical Statistics B
Non-Statistics Students: ST220 Introduction to Mathematical Statistics

Module web page

Module aims

Designed experiments are used in industry, agriculture, medicine and many other areas of activity to test hypotheses, to learn about processes and to predict future responses. The primary purpose of experimentation is to determine the relationship between a response variable and the settings of a number of experimental variables (or factors) that are presumed to affect it. Experimental design is the discipline of determining the number and order (spatial or temporal) of experimental runs, and the setting of the experimental variables.

This is a first course in designed experiments. The elementary theory of experimental design relies on linear models, while the practice involves important eliciting and communication skills. In this course we shall see how the theory links common designs such as the randomised complete block and split-plot to the underlying model. The course will commence with a review of linear model theory and some simple designs; we shall then examine the basic principles of experimental design and analysis, e.g. the concepts of randomisation and replication together with the blocking in designs and the combination of experimental treatments (factorial structure). Classical design structures are developed through the separate consideration of block and treatment structure, and the use of analysis of variance to explore differences between treatments for different types of design is explored. Throughout, diagnostic and analysis methods for the examination of practical experiments will be developed. A significant part of the course will be spent developing aspects of factorial design theory, including the theory and practice of confounding and of fractional designs. We will see how the exigencies of design in an industrial context have led to further theory and different emphases from classical design. This will include the use of regression in response surface modelling. Further topics such as repeated measures, non-linear design and optimal design theory may be included if time allows. Practical examples from many different application areas will be given throughout, with an emphasis on analysis using R.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

The module will typically cover:

- A review of linear model theory and some simple design,
- Basic principles of experimental design and analysis such as randomisation and replication,
- Blocking in designs and combination of experimental treatments,
- Factorial design theory including theory and practice of confounding and fractional designs,
- Analysis of Variance to explore differences between treatments for different types of designs,
- Regression in response surface modelling.
  If time allows additional topics may be included such as repeated measures, non-linear design and optimal design theory.

Learning outcomes

By the end of the module, students should be able to:

- Distinguish between different designs and recognise their efficiency / utility
- Describe the basic principles behind designed experiments;
- Construct the design matrix for simple experiments and estimate their parameters
- Perform an analysis of variance on standard experimental designs
- Perform diagnostic tests on the results from a designed experiment
- Take a practical design problem and determine an optimal or robust solution

Indicative reading list

View reading list on Talis Aspire

Subject specific skills

-Specify the model, construct the design matrix and estimate the parameters of any design based on a general linear model.
-Access design and analysis software that will take the computational labour out of both tasks.
-Communicate the advantages/disadvantages of particular designs to others; match designs with useful structures in most circumstances; interpret outputs from more complex (non-orthogonal) designs.

Transferable skills

-Design and analyse simple experiments to test hypotheses, and interpret the outcomes; understand the power of factorial design structures, and the important concepts of confounding and aliasing.

Study

Study time

Type	Required	Optional
Lectures	30 sessions of 1 hour (20%)	2 sessions of 1 hour
Tutorials	8 sessions of 1 hour (5%)	
Private study	82 hours (55%)	
Assessment	30 hours (20%)	
Total	150 hours	

Private study description

Weekly revision of lecture notes and materials, wider reading, practice exercises and preparing for examination.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group D6

	Weighting	Study time
Assignment 1	10%	15 hours

The assignment will contain a number of questions for which solutions and / or written responses will be required.
The number of words noted refers to the amount of time in hours that a well-prepared student who has attended lectures and carried out an appropriate amount of independent study on the material could expect to spend on this assignment. 500 words is equivalent to one page of text, diagrams, formula or equations; your ST305 Assignment 1 should not exceed 15 pages in length.

Assignment 2	10%	15 hours

The assignment will contain a number of questions for which solutions and / or written responses will be required.
The number of words noted refers to the amount of time in hours that a well-prepared student who has attended lectures and carried out an appropriate amount of independent study on the material could expect to spend on this assignment. 500 words is equivalent to one page of text, diagrams, formula or equations; your ST305 Assignment 2 should not exceed 15 pages in length.

In-person Examination	80%

The examination paper will contain four questions, of which the best marks of THREE questions will be used to calculate your grade.

- Answerbook Pink (12 page)
- Students may use a calculator
- Cambridge Statistical Tables (blue)

Assessment group R2

	Weighting	Study time
In-person Examination - Resit	100%	

The examination paper will contain four questions, of which the best marks of THREE questions will be used to calculate your grade.

- Answerbook Pink (12 page)
- Cambridge Statistical Tables (blue)

Feedback on assessment

Marked assignments will be available for viewing at the support office within 20 working days of

the submission deadline. Cohort level feedback and solutions will be provided, and students will be given the opportunity to receive feedback via face-to-face meetings.

Solutions and cohort level feedback will be provided for the examination.

Past exam papers for ST305

Availability

Anti-requisite modules

If you take this module, you cannot also take:

- ST410-15 Designed Experiments with Advanced Topics

Courses

This module is Optional for:

- Year 3 of UCSA-G4G1 Undergraduate Discrete Mathematics
- Year 3 of UCSA-G4G3 Undergraduate Discrete Mathematics
- Year 4 of UCSA-G4G4 Undergraduate Discrete Mathematics (with Intercalated Year)
- Year 4 of UCSA-G4G2 Undergraduate Discrete Mathematics with Intercalated Year
- USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
    - Year 3 of G300 Mathematics, Operational Research, Statistics and Economics
    - Year 4 of G300 Mathematics, Operational Research, Statistics and Economics

This module is Option list A for:

- USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
    - Year 3 of G1G3 Mathematics and Statistics (BSc MMathStat)
    - Year 4 of G1G3 Mathematics and Statistics (BSc MMathStat)
- USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
    - Year 4 of G1G4 Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
    - Year 5 of G1G4 Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
- Year 3 of USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
- Year 4 of USTA-GG17 Undergraduate Mathematics and Statistics (with Intercalated Year)
- Year 3 of USTA-Y602 Undergraduate Mathematics,Operational Research,Statistics and Economics
- Year 4 of USTA-Y603 Undergraduate Mathematics,Operational Research,Statistics,Economics (with Intercalated Year)

This module is Option list B for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)

    - Year 4 of G105 Mathematics (MMath) with Intercalated Year
    - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G100 Undergraduate Mathematics (BSc)
    - Year 3 of G100 Mathematics
    - Year 3 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
    - Year 4 of G103 Mathematics (MMath)
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
    - Year 3 of G106 Mathematics (MMath) with Study in Europe
    - Year 4 of G106 Mathematics (MMath) with Study in Europe
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year

This module is Option list C for:

- Year 3 of USTA-G302 Undergraduate Data Science
- Year 3 of USTA-G304 Undergraduate Data Science (MSci)
- Year 4 of USTA-G303 Undergraduate Data Science (with Intercalated Year)

This module is Option list D for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- Year 5 of USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated

This module is Option list E for:

- Year 4 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- Year 5 of USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated

This module is Option list F for:

- Year 3 of USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
- USTA-G301 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics (with Intercalated
    - Year 3 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
    - Year 4 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)