# ST410-15 Designed Experiments with Advanced Topics

## 21/22

**Department**
Statistics
**Level**
Undergraduate Level 4
**Module leader**
Samuel Touchard
**Credit value**
15
**Module duration**
10 weeks
**Assessment**
Multiple
**Study location**
University of Warwick main campus, Coventry

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## 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.

Students will be given selected advanced research material for independent study and examination.

## 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.
  . Specific higher-level material for ST410 (not for ST305 which is the third year variant) include principles of robust design and Analysis of Covariance.
  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:

- Describe the basic principles behind designed experiments

- Show the relationship between a designed experiment, the underlying linear model and the analysis of the resulting data
- Construct the design matrix for a simple experiment and estimate the model parameters
- Perform an analysis of variance on standard experimental designs
- Distinguish between different types of design and recognise their efficiency / utility
- Perform diagnostic tests on the results from a designed experiment.

## Indicative reading list

Reading lists can be found in Talis

Specific reading list for the module

## 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.

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## 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

Study of advanced topic, 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.

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## 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 D4

| | Weighting | Study time | Eligible for self-certification |
|---|---|---|---|
| Assignment 1 | 10% | 15 hours | Yes (extension) |

Due Week 7 of Term 2.
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 ST410 Assignment 1 should not exceed 15 pages in length.

| | | | |
|---|---|---|---|
| Assignment 2 | 10% | 15 hours | Yes (extension) |

Due in Week 2 of Term 3.
The assignment will contain a number of questions for which solutions and / or written responses will be required.

The number of words noted below 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 ST410 Assignment 2 should not exceed 15 pages in length.

| | | | |
|---|---|---|---|
| On-campus Examination | 80% | | No |

The examination will contain one compulsory question on the advanced topic and four additional questions of which the best marks of TWO questions will be used to calculate your grade.

~Platforms - Moodle

### Assessment group R1

| | Weighting | Study time | Eligible for self-certification |
|---|---|---|---|
| In-person Examination - Resit | 100% | | No |

The examination will contain one compulsory question on the advanced topic and four additional questions of which the best marks of TWO questions will be used to calculate your grade.

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### 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 ST410

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## Availability

### Anti-requisite modules

If you take this module, you cannot also take:

- ST305-15 Designed Experiments

## Courses

This module is Optional for:

- TMAA-G1PE Master of Advanced Study in Mathematical Sciences
  - Year 1 of G1PE Master of Advanced Study in Mathematical Sciences
  - Year 1 of G1PE Master of Advanced Study in Mathematical Sciences
- Year 1 of TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics
- Year 1 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- Year 1 of TSTA-G4P1 Postgraduate Taught Statistics
- 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:

- 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
- 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)

This module is Option list B for:

- Year 4 of USTA-G304 Undergraduate Data Science (MSci)
- Year 4 of UCSA-G4G3 Undergraduate Discrete Mathematics

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)