

ST230-10 Mathematical Statistics

24/25

Department

Statistics

Level

Undergraduate Level 2

Module leader

Nicholas Tawn

Credit value

10

Module duration

10 weeks

Assessment

Multiple

Study location

University of Warwick main campus, Coventry

Description

Introductory description

To provide a systematic introduction to major ideas of statistical inference, with an emphasis on likelihood methods of modelling, estimation, and testing.

Pre-requisites:

- ST228 Mathematical Methods for Statistics and Probability, and
- ST229 Probability for Mathematical Statistics.

This module is core for students with their home department in Statistics.

It is **not** available to other students, for whom ST232/ST233 (Introduction to Mathematical Statistics) is provided as an alternative.

Leads To: many ST3 and ST4 modules.

[Module web page](#)

Module aims

To provide a systematic introduction to major ideas of statistical inference, with an emphasis on the mathematical underpinnings of modelling using likelihoods, and on model selection and

testing.

A good understanding of these ideas is crucial preparation for further investigation of applied and methodological statistics, machine learning, and the core statistical aspects of data science.

The module will consolidate the initial understanding developed in the first-year common core for Statistics students.

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.

This module continues the systematic study of the theory of mathematical statistics.

1. The notion of a parametrized statistical model for data.
2. The definition of likelihood and examples of using it to compare possible parameter values.
3. Parameter estimates and in particular maximum likelihood estimates. Examples including estimated means and variances for Gaussian variables.
4. The notion of estimator and its sampling distribution; interval estimation. Examples of calculating sampling distributions.
5. Frequentist approaches to model comparison and selection; hypothesis testing and p-values.
6. The Bayesian approach to statistical inference; concepts of prior, posterior, conjugacy.
7. Bayesian estimators and credible intervals, posterior predictive checking.
8. Bayesian model selection.

Learning outcomes

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

- describe the main notions of statistical inference including a (parametrized) statistical model, an estimator and its sampling distribution, and hypothesis tests; and to understand their uses and limitations.
- calculate maximum likelihood estimators in a variety of examples.
- use likelihood ratios to compare models and to design hypothesis tests in a variety of examples.
- derive properties of sampling distributions of estimators in a variety of examples.
- compare models using methods of model selection in both a frequentist and Bayesian setting.
- communicate solutions to problems accurately with structured and coherent arguments.

Indicative reading list

Main reference book for this module:

1. Statistical Inference, G. Casella and R. L. Berger.
2. Bayesian Data Analysis, A. Gelman et al.

Further possibilities for reference:

3. Probability and statistics by example: 1: Basic probability and statistics, Y. M. Suhov, M. Kelbert.
4. Introductory Statistics, S.M. Ross.
5. Introduction to Probability and Statistics for Engineers and Scientists, S. M. Ross.

[View reading list on Talis Aspire](#)

Subject specific skills

Select and apply appropriate mathematical and/or statistical techniques.

Create structured and coherent arguments communicating them in written form.

Construct and develop logical mathematical arguments with clear identification of assumptions and conclusions.

Transferable skills

Written communication skills: Students complete written assessments that require precise and unambiguous communication in the manner and style expected in mathematical sciences.

Verbal communication skills: Students are encouraged to discuss and debate formative assessment and lecture material within small-group tutorials sessions. Students can continually discuss specific aspects of the module with the module leader. This is facilitated by statistics staff office hours.

Problem-solving skills: The module requires students to solve problems with complex solutions and this requirement is embedded in the module's assessment.

Study

Study time

| Type | Required | Optional |
|---------------|-----------------------------|----------------------|
| Lectures | 20 sessions of 1 hour (20%) | 2 sessions of 1 hour |
| Seminars | 5 sessions of 1 hour (5%) | |
| Tutorials | 5 sessions of 1 hour (5%) | |
| Private study | 60 hours (60%) | |
| Assessment | 10 hours (10%) | |
| Total | 100 hours | |

Private study description

Weekly revision of lecture notes and materials, wider reading and practice exercises, working on problem sets 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.

Assessment group D1

| | Weighting | Study time | Eligible for self-certification |
|--------------------|------------------|-------------------|--|
| In term assessment | 10% | 8 hours | No |

There will be approximately weekly problem sets. Each problem set will contain a number of individual questions based on the material delivered in the lectures. Problem sheets are supported by seminars, including both analytical and computational tasks. Assessment is based on solutions to the problems and engagement with in-class problems.

The preparation and completion time 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 assessment.

| | | | |
|-------------------------------------|-----|---------|----|
| Mathematical Statistics examination | 90% | 2 hours | No |
|-------------------------------------|-----|---------|----|

You will be required to answer all questions on this examination paper.

- Answerbook Pink (12 page)
- Students may use a calculator

Assessment group R1

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

You will be required to answer all questions on this examination paper.

- Answerbook Pink (12 page)
- Students may use a calculator

Feedback on assessment

Individual feedback will be provided on problem sheets by class tutors.

Cohort level feedback will be provided for the examination.

Students are actively encouraged to make use of office hours to build up their understanding, and to view all their interactions with lecturers and class tutors as feedback.

[Past exam papers for ST230](#)

Availability

Courses

This module is Core for:

- Year 2 of USTA-G302 Undergraduate Data Science
- Year 2 of USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
- Year 2 of USTA-Y602 Undergraduate Mathematics, Operational Research, Statistics and Economics