ST232-15 Introduction to Mathematical Statistics

26/27

Department
Statistics
Level
Undergraduate Level 2
Module leader
Massimiliano Tamborrino
Credit value
15
Module duration
10 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

The purpose of this module is to provide a systematic introduction to major ideas of statistical inference, with an emphasis on likelihood methods of estimation and testing.

Pre-requisites: ST120 Introduction to Probability.

The ST121 Statistical Laboratory module is not a pre-requisite. ST121 covers a number of useful examples in Statistics, and will be a useful enrichment for non-Statistics students going on to take this module, but does not cover the general theory on which "Introduction to Mathematical Statistics" concentrates.

This module is available to non-Statistics Department **second year** mathematical science students who wish to fulfil prerequisites for final years statistics modules, in place of the equivalent modules ST229 and ST230 which are available for Statistics Department students only. Non-Statistics Department students in their **third year** should take ST352 Introduction to Mathematical Statistics (for Finalists).

Leads to: many ST3 and ST4 modules.

Module web page

Module aims

To introduce systematically the major ideas of statistical inference with an emphasis on likelihood methods of estimation 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 and extend the initial understanding of probability developed in the first-year module ST120.

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 covers the systematic study of the theory of mathematical statistics.

1. Probability techniques as used in mathematical statistics, including notion of random variable, expectation, variance, covariance, conditional expectation, and moment generating functions
2. Standard families of Probability distributions: Binomial, Geometric, Poisson, Exponential, Gamma, Gaussian.
3. Markov inequality and Chebyshev inequality.
4. The weak law of large numbers and central limit theorem.
5. The Multivariate Gaussian distribution. Orthogonality and Independence for jointly Gaussian random variables.
6. Distributions derived from the Gaussian: Chi-squared, t and F.
7. The notion of a parametrized statistical model, and examples.
8. Likelihood including maximum likelihood estimates and use of likelihood ratios to compare hypotheses.
9. The repeated sampling principle: bias and MSE, confidence intervals and p-values.
10. Fisher's theorem on Gaussian sampling, and its extension to linear regression.

Learning outcomes

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

- Demonstrate facility with the mathematical concepts of conditional probability, conditional expectation and moment generating functions.
- Calculate with and prove more advanced notions of probability including properties of multivariate Gaussian distributions, the law of large numbers, and the central limit theorem.
- Describe the main notions of statistical inference including a (parametrized) statistical model, an estimator and its sampling distribution, confidence intervals and hypothesis tests.
- Calculate maximum likelihood estimators and derive properties of sampling distributions of estimators in a variety of examples.
- Construct confidence intervals using pivots.

- Perform hypothesis testing with likelihood ratio tests in a variety of examples. Compute p-values and calculate probabilities of Type I and Type II errors.
- Communicate solutions to problems accurately with structured and coherent arguments.

Indicative reading list

Reading lists can be found in Talis

Specific reading list for the module

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 develop mathematical arguments 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
Lectures	30 sessions of 1 hour (20%)
Seminars	5 sessions of 1 hour (3%)
Private study	98 hours (65%)
Assessment	17 hours (11%)
Total	150 hours

Private study description

Reviewing lecture material, working through exercises set in lectures and lecture notes, working through exercise sheets, supplementary reading, preparing for seminars.

Other activity description

Revision support equivalent to approximately 2 hours.

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 D3

	Weighting	Study time	Eligible for self-certification
Multiple Choice Quizzes	10%	15 hours	No

A set of multiple choice quizzes which will take place during the term that the module is delivered. The problems in the quizzes will require the application of problem-solving methods or calculation to derive a solution. The preparation and completion time 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 completing the assessment.

Centrally-timetabled examination (On-campus)	90%	2 hours	No

You will be required to answer all questions in the relevant sections of this examination paper. The study time noted refers to the length of the exam in hours.

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

Assessment group R3

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

You will be required to answer all questions in the relevant sections of this examination paper.

	Weighting	Study time	Eligible for self-certification

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

Feedback on assessment

Cohort-level feedback will be provided for the in-term assessment and the exam.

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 ST232

Availability

Anti-requisite modules

If you take this module, you cannot also take:

- ST233-15 Introduction to Mathematical Statistics
- ST352-15 Introduction to Mathematical Statistics (for Finalists)

Courses

This module is Core for:

- UCSA-G4G1 Undergraduate Discrete Mathematics
  - Year 2 of G4G1 Discrete Mathematics
  - Year 2 of G4G1 Discrete Mathematics
- UCSA-G4G3 Undergraduate Discrete Mathematics
  - Year 2 of G4G1 Discrete Mathematics
  - Year 2 of G4G3 Discrete Mathematics
- Year 2 of UCSA-G4G4 Undergraduate Discrete Mathematics (with Intercalated Year)
- Year 2 of UCSA-G4G2 Undergraduate Discrete Mathematics with Intercalated Year

This module is Optional for:

- Year 2 of UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
- UMAA-G100 Undergraduate Mathematics (BSc)
  - Year 2 of G100 Mathematics
  - Year 2 of G100 Mathematics
  - Year 2 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
  - Year 2 of G100 Mathematics
  - Year 2 of G103 Mathematics (MMath)

    - Year 2 of G103 Mathematics (MMath)
- Year 2 of UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
- Year 2 of UMAA-G1NC Undergraduate Mathematics and Business Studies
- Year 2 of UMAA-G1N2 Undergraduate Mathematics and Business Studies (with Intercalated Year)
- Year 2 of UMAA-GL11 Undergraduate Mathematics and Economics
- Year 2 of UECA-GL12 Undergraduate Mathematics and Economics (with Intercalated Year)
- Year 2 of UMAA-G101 Undergraduate Mathematics with Intercalated Year