ST233-15 Introduction to Mathematical Statistics

23/24

Department
Statistics
Level
Undergraduate Level 2
Module leader
Krzysztof Latuszynski
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 ST117 Introduction to Statistical Modelling module is not a pre-requisite. ST117 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 ST232/ST233 concentrates.

This module is available to mathematical science students from outside the Statistics Department and NOT IN THEIR SECOND YEAR 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 second year should take ST232 instead of this module.

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. The weak law of large numbers and central limit theorem.
4. The Multivariate Gaussian distribution. Orthogonality and Independence for jointly Gaussian random variables.
5. Distributions derived from the Gaussian: Chi-squared, t and F.
6. The notion of a parametrized Statistical model, and examples.
7. Likelihood including maximum likelihood estimates and use of likelihood ratios to compare hypotheses.
8. The repeated sampling principle: bias and MSE, confidence intervals and p-values.
9. 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 more advanced notions of probability needed in mathematical statistics 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, and hypothesis tests.
- Calculate maximum likelihood estimators in a variety of examples and derive properties of sampling distributions of estimators in a variety of examples, and thereby construct confidence intervals.

- Calculate with likelihood ratios to construct hypothesis tests in a variety of examples including the classical t and F tests.
- 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.
   Further possibilities for reference:
2. Probability and statistics by example: 1: Basic probability and statistics, Y. M. Suhov, M. Kelbert (available online through Warwick Reading Lists)
3. Introduction to probability theory and mathematical statistics, V. K. Rohatgi; A. K. Md. Ehsanes Saleh
4. All of statistics: a concise course in statistical inference, Larry Wasserman
5. Mathematical Statistics, Jun Shao

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	30 sessions of 1 hour (20%)	2 sessions of
Seminars	5 sessions of 1 hour (3%)	
Private study	105 hours (70%)	
Assessment	10 hours (7%)	
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.

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 D

	Weighting	Study time
Problem set 1	2%	2 hours
A problem sheet that include problem solving and calculations. Problem sheets will be set at fortnightly intervals.		
Problem set 2	3%	2 hours
A problem sheet that include problem solving and calculations. Problem sheets will be set at fortnightly intervals.		
Problem set 3	2%	2 hours
A problem sheet that include problem solving and calculations. Problem sheets will be set at fortnightly intervals.		
Problem set 4	3%	2 hours
A problem sheet that include problem solving and calculations. Problem sheets will be set at fortnightly intervals.		
Introduction to Mathematical Statistics examination	90%	2 hours
You will be required to answer all questions on this examination paper.		

	Weighting	Study time

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

Assessment group R

	Weighting	Study time
In-person Examination - Resit	100%	

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 available on 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 ST233

Availability

Courses

This module is Option list B for:

- Year 4 of UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
- UMAA-G100 Undergraduate Mathematics (BSc)
    - Year 3 of G100 Mathematics
    - Year 3 of G100 Mathematics
    - Year 3 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
    - Year 3 of G100 Mathematics
    - Year 3 of G103 Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year