Accessibility statement

Introduction to Probability & Statistics - MAT00004C

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- **Department**: Mathematics
- **Module co-ordinator**: Dr. Jessica Hargreaves
- **Credit value**: 20 credits
- **Credit level**: C
- **Academic year of delivery**: 2020-21
  - See module specification for other years: 2018-19 2019-20

Module will run

Occurrence	Teaching cycle
A	Autumn Term 2020-21

Module aims

The first years of all mathematics programmes are designed to give students a thorough grounding in a wide spectrum of mathematical ideas, techniques and tools in order to equip them for the later stages of their course. During first year, as well as consolidating, broadening and extending core material from pre-University study, we initiate a cultural transition to the rigorous development of mathematics which is characteristic at University. Students will develop both their knowledge of mathematics as a subject and their reasoning and communication skills, through lectures, tutorials, seminars, guided self-study, independent learning and project work. This development is addressed in all of our first year modules, although different modules have a different emphasis.

In addition to these broad aims, this module: introduces the basic concepts of probability theory and statistics, illustrated by a full range of examples and applications; introduces an important statistical computing package (R); provides secure and solid foundations for higher level probability and mathematical statistics modules, available in Stage 2.

Module learning outcomes

Demonstrate competence in a wide range of essential elementary concepts, techniques and applications of probability and statistics (see below).

At the end of the module the student should be able to:

- model simple experiments using probability theory;
- perform standard probability calculations;
- calculate conditional probabilities and use Bayes' theorem;
- understand the concepts of random variables and distributions;
- compute moments of random variables;
- work with independent as well as with correlated random variables;
- understand the key concepts of statistical modelling;
- understand standard methods that are used to summarise data;
- be able to differentiate between common types of data, and display them appropriately;
- apply simple formal statistical techniques and interpret the results;
- use graphical and numerical techniques for data analysis by hand and in R;
- feel comfortable with the use of computers for data analysis using R;
- proceed to all probability and statistics modules in the degree programme.

Module content

- Probability
    1. Probability as a set function, sample space, event. Axioms of probability.
    2. Properties of probability (probability of the union of events, the complement of an event, etc.)
    3. Conditional probability. Bayes' Theorem and applications.
    4. Independence of events.
- Random variables
    1. Definition, cumulative distribution function.
    2. Discrete random variables and their distribution. Common discrete distributions.
    3. Continuous random variables, the density function. Common continuous distributions.
    4. Expectation and variance of random variables and functions of random variables.
    5. Chebychev's inequality
    6. Transformations of random variables.
- Jointly distributed random variables
    1. Joint distributions of discrete random variables, joint distribution functions.
    2. Jointly continuous random variables, joint density functions.
    3. Independence of random variables.
    4. Expectations of functions of jointly distributed random variables.
    5. Covariance and the correlation coefficient.
- Exploratory data analysis
    1. Tabular summaries of data. Graphical summaries: line plot, box plot, bar chart, histogram, stem and leaf plot, scatterplot for bivariate data, etc.
    2. Measures of center of a data set (mean, median, mode) , spread/variability (standard deviation, range, interquartile range) and skewness.
    3. Empirical distribution function, empirical density function, quantiles.
- Properties of random samples
    1. The law of large numbers.
    2. Central limit theorem.
    3. Sample distributions.
    4. Computer simulations.
- Statistical models and parameter estimation
    1. Examples of statistical models.
    2. Unbiased estimators.
    3. Sample mean, sample variance and sample covariance.
    4. Confidence intervals for the mean.
    5. Maximum likelihood estimators.
- Simple linear regression
    1. The simple linear regression model.
    2. Least squares estimators of the slope and intercept.
    3. Analysis of variance and the coefficient of determination.
    4. Prediction using the simple linear regression model.

Assessment

Task	Length	% of module mark
24 hour open exam Introduction to Probability & Statistics	N/A	60
Essay/coursework 6 Assignments	N/A	40

Special assessment rules

None

Reassessment

Task	Length	% of module mark
24 hour open exam Introduction to Probability & Statistics	N/A	60
Essay/coursework 6 Assignments	N/A	40

Module feedback

- Immediate feedback via online quizzes.
- Current Department policy on feedback is available in the undergraduate student handbook. Coursework and examinations will be marked and returned in accordance with this policy.

Indicative reading

A Modern Introduction to Probability and Statistics, Understanding Why and How by F.M. Dekking et.al., Springer 2005.