1. **Title of the module**

MAST5007 (MA5507) - Mathematical Statistics

MAST6007 (MA6507) - Mathematical Statistics

1. **School or partner institution which will be responsible for management of the module**

School of Mathematics, Statistics and Actuarial Science

1. **The level of the module (Level 4, Level 5, Level 6 or Level 7)**

Level 5 (MAST5007), Level 6 (MAST6007)

1. **The number of credits and the ECTS value which the module represents**

15 credits (7.5 ECTS)

1. **Which term(s) the module is to be taught in (or other teaching pattern)**

Autumn

1. **Prerequisite and co-requisite modules**

Level 5 module:

Prerequisite: MAST4006 (Mathematical Methods 1), MAST4007 (Mathematical Methods 2), MAST4009 (Probability), MAST4011 (Statistics)

Co-requisite: None

Level 6 module:

Prerequisite: material equivalent to that covered above.

Co-requisite: None

1. **The programmes of study to which the module contributes**

BSc Mathematics, BSc Mathematics and Statistics, BSc Financial Mathematics, BA Mathematics, Accounting and Finance, BSc Actuarial Science (including programmes with a Year in Industry), BSc Mathematics with Secondary Education, BSc Mathematics with a Foundation Year, BSc Actuarial Science with a Foundation Year, MMath Mathematics, MMathStat Mathematics and Statistics, International MSc in Statistics, International MSc in Statistics with Finance

1. **The intended subject specific learning outcomes.
On successfully completing the level 5 module students will be able to:**

8.1 demonstrate knowledge and critical understanding of the well-established principles within probability and inference;

8.2 demonstrate the capability to use a range of established techniques and a reasonable level of skill in calculation and manipulation of the material to solve problems in the following areas: joint, marginal and conditional probability distributions, to derive distributions of transformed random variables, to calculate point and interval estimates of parameters and to perform tests of hypotheses;

8.3 apply the concepts and principles in probability and inference in well-defined contexts beyond those in which they were first studied, showing the ability to evaluate critically the appropriateness of different tools and techniques.

**On successfully completing the level 6 module students will be able to:**

8.4 demonstrate systematic understanding of key aspects of frequentist and Bayesian statistics;

8.5 demonstrate the capability to deploy established approaches accurately to analyse and solve problems using a reasonable level of skill in calculation and manipulation of the material in the following areas: joint, marginal and conditional probability distributions, to derive distributions of transformed random variables, to calculate point and interval estimates of parameters, to perform tests of hypotheses, prior and posterior distributions, conjugate prior, loss function, Bayesian estimators and credible intervals;

8.6 apply key aspects of frequentist and Bayesian statistics in well-defined contexts, showing judgement in the selection and application of tools and techniques.

1. **The intended generic learning outcomes.
On successfully completing the level 5 module students will be able to:**

Demonstrate an increased ability to:

9.1 manage their own learning and make use of appropriate resources;

9.2 understand logical arguments, identifying the assumptions made and the conclusions drawn;

9.3 communicate straightforward arguments and conclusions reasonably accurately and clearly;

9.4 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;

9.5 solve problems relating to qualitative and quantitative information;

9.6 make use of information technology skills such as online resources (moodle), internet communication;

9.7 communicate technical material competently;

9.8 demonstrate an increased level of skill in numeracy and computation.

**On successfully completing the level 6 module students will be able to:**

9.9 manage their own learning and make use of appropriate resources;

9.10 understand logical arguments, identifying the assumptions made and the conclusions drawn;

9.11 communicate straightforward arguments and conclusions reasonably accurately and clearly;

9.12 manage their time and use their organisational skills to plan and implement efficient and effective modes of working;

9.13 solve problems relating to qualitative and quantitative information;

9.14 make competent use of information technology skills such as online resources (moodle), internet communication;

9.15 communicate technical material competently;

9.16 demonstrate an increased level of skill in numeracy and computation;

9.17 demonstrate the acquisition of the study skills needed for continuing professional development.

1. **A synopsis of the curriculum**

**Probability:** Joint distributions of two or more discrete or continuous random variables. Marginal and conditional distributions. Independence. Properties of expectation, variance, covariance and correlation. Poisson process and its application. Sums of random variables with a random number of terms.

**Transformations of random variables:** Various methods for obtaining the distribution of a function of a random variable —method of distribution functions, method of transformations, method of generating functions. Method of transformations for several variables. Convolutions. Approximate method for transformations.

**Sampling distributions:** Sampling distributions related to the Normal distribution — distribution of sample mean and sample variance; independence of sample mean and variance; the t distribution in one- and two-sample problems.

**Statistical inference:** Basic ideas of inference — point and interval estimation, hypothesis testing.

**Point estimation:** Methods of comparing estimators — bias, variance, mean square error, consistency, efficiency. Method of moments estimation. The likelihood and log-likelihood functions. Maximum likelihood estimation.

**Hypothesis testing:** Basic ideas of hypothesis testing — null and alternative hypotheses; simple and composite hypotheses; one and two-sided alternatives; critical regions; types of error; size and power. Neyman-Pearson lemma. Simple null hypothesis versus composite alternative. Power functions. Locally and uniformly most powerful tests. Composite null hypotheses. The maximum likelihood ratio test.

**Interval estimation:** Confidence limits and intervals. Intervals related to sampling from the Normal distribution. The method of pivotal functions. Confidence intervals based on the large sample distribution of the maximum likelihood estimator – Fisher information, Cramer-Rao lower bound. Relationship with hypothesis tests. Likelihood-based intervals.

In addition, for level 6 students:

**Bayesian Inference:** Prior and posterior distributions, conjugate prior, loss function, Bayesian estimators and credible intervals. Examples of application.

1. **Reading list (Indicative list, current at time of publication. Reading lists will be published annually)**

MILLER, I. and MILLER, M. (2014) John E. Freund’s Mathematical Statistics with Applications. 8th international edition. Pearson Education, Prentice Hall, New Jersey.

LINDLEY, D.V. and SCOTT, W.F. (1995) New Cambridge Statistical Tables. 2nd edition.

HOGG, R., CRAIG, A. and McKEAN, J. (2003) Introduction to Mathematical Statistics. 6th international edition.

LARSON, H. J. (1982) Introduction to Probability Theory and Statistical Inference. 3rd edition.

SPIEGEL, M. R, SCHILLER, J. and ALU SRINIVASAN, R. (2013) Schaum’s Outline of Probability and Statistics. 4th edition.

LEE, P. M. (2012) [for level 6 students] Bayesian Statistics an Introduction. 4th edition. (ebook)

1. **Learning and teaching methods**

Total contact hours: 44

Private study hours: 106

Total study hours: 150

1. **Assessment methods**
	1. Main assessment methods

**Level 5**

Assessment 1 Exercises, requiring on average between 10 and 15 hours to complete 15%

Assessment 2 Exercises, requiring on average between 10 and 15 hours to complete 15%

Examination 2 hours 70%

The coursework mark alone will not be sufficient to demonstrate the student’s level of achievement on the module.

**Level 6**

Assessment 1 Exercises, requiring on average between 10 and 15 hours to complete 15%

Assessment 2 Exercises, requiring on average between 10 and 15 hours to complete 15%

Examination 2 hours 70%

The coursework mark alone will not be sufficient to demonstrate the student’s level of achievement on the module.

13.2 Reassessment methods

Like-for-like

1. **Map of module learning outcomes (sections 8 & 9) to learning and teaching methods (section12) and methods of assessment (section 13)**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Level 5** **Module learning outcome** | 8.1 | 8.2 | 8.3 | 9.1 | 9.2 | 9.3 | 9.4 | 9.5 | 9.6 | 9.7 | 9.8 |
| **Learning/ teaching method** |  |  |  |  |  |  |  |  |  |  |  |
| Private Study  | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Lectures/Exercise classes | **X** | **X** | **X** |  | **X** | **X** |  | **X** |  | **X** | **X** |
| Revision classes | **X** | **X** | **X** |  | **X** | **X** |  | **X** |  | **X** | **X** |
| **Assessment method** |  |  |  |  |  |  |  |  |  |  |  |
| Examination | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |  | **X** | **X** |
| Coursework | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Level 6 Module learning outcome** | 8.4 | 8.5 | 8.6 | 9.9 | 9.10 | 9.11 | 9.12 | 9.13 | 9.14 | 9.15 | 9.16 | 9.17 |
| **Learning/ teaching method** |  |  |  |  |  |  |  |  |  |  |  |  |
| Private Study  | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Lectures/Exercise classes | **X** | **X** | **X** |  | **X** | **X** |  | **X** |  | **X** | **X** |  |
| Revision classes | **X** | **X** | **X** |  | **X** | **X** |  | **X** |  | **X** | **X** |  |
| **Assessment method** |  |  |  |  |  |  |  |  |  |  |  |  |
| Examination | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |  | **X** | **X** | **X** |
| Coursework | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |

1. **Inclusive module design**

The School recognises and has embedded the expectations of current equality legislation, by ensuring that the module is as accessible as possible by design. Additional alternative arrangements for students with Inclusive Learning Plans (ILPs)/declared disabilities will be made on an individual basis, in consultation with the relevant policies and support services.

The inclusive practices in the guidance (see Annex B Appendix A) have been considered in order to support all students in the following areas:

a) Accessible resources and curriculum

b) Learning, teaching and assessment methods

1. **Campus(es) or centre(s) where module will be delivered**

Canterbury

1. **Internationalisation**

This module is based on mathematical principles. Mathematics and statistics are international languages with techniques developed and refined by mathematicians and statisticians across the globe. Mastery of the subject-specific learning outcomes, 8.1 to 8.6, will equip students to apply the theories and techniques of this module in a wide range of international contexts. The module team is drawn from the School of Mathematics, Statistics and Actuarial Science, which includes many members of staff with international experience of teaching and research collaboration.

In compiling the reading list, consideration has been given to the range of texts that are available internationally and a selection of texts has been identified to complement the delivery of the material.

Examples with an international dimension are included in the module where appropriate.

The support SMSAS provides to its students is also internationally attuned given our international student body.

**FACULTIES SUPPORT OFFICE USE ONLY**

**Revision record – all revisions must be recorded in the grid and full details of the change retained in the appropriate committee records.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Date approved | Major/minor revision | Start date of the delivery of revised version | Section revised | Impacts PLOs (Q6&7 cover sheet) |
| July 2023 | Minor | September 2023 | 13 |  |
|  |  |  |  |  |