1. **Title of the module**

MAST6011 – Bayesian Statistics with Stan and Python

MAST7011 – Bayesian Statistics with Stan and Python

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)**

MAST6011 Level 6

MAST7011 Level 7

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)**

Spring

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

**Level 6:** Pre-requisite: MAST5007: Mathematical Statistics

Co-requisite: None

**Level 7:** Pre-requisite: None

Co-requisite: MAST7291: Probability and Statistics for Data Science

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

MMath Mathematics, also with a year in industry; MSc in Statistical Data Science, also with an Industrial Placement.

1. **The intended subject specific learning outcomes.
On successfully completing the level 6 module students will be able to:**

8.1 demonstrate systematic understanding of key aspects of Bayesian Statistics;

8.2 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: derivation of posterior distributions; computation of posterior summaries, including the predictive distribution; construction of Bayesian hierarchical models and their estimation using Markov chain Monte Carlo methods; critical evaluation and interpretation of software output;

8.3 apply key aspects of Bayesian Statistics in well-defined contexts, showing judgement in the selection and application of tools and techniques;

8.4 show judgement in the selection and application of techniques in Stan and Python.

**On successfully completing the level 7 module students will be able to:**

8.5 demonstrate systematic understanding of key aspects of Bayesian Statistics;

8.6 demonstrate the capability to solve complex problems using a very good level of skill in calculation and manipulation of the material in the following areas: derivation of posterior distributions; computation of posterior summaries, including the predictive distribution; construction of Bayesian hierarchical models and their estimation using Markov chain Monte Carlo methods; critical evaluation and interpretation of software output;

8.7 apply a range of concepts and principles in Bayesian Statistics in loosely defined contexts, showing good judgement in the selection and application of tools and techniques;

8.8 make effective and well-considered use of Stan and Python to apply techniques in Bayesian Statistics.

1. **The intended generic learning outcomes.**

 **On successfully completing the level 6 module students will be able 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 competent use of information technology skills such as Stan and Python, online resources (Moodle), internet communication;

9.7 communicate technical material competently;

* 1. demonstrate an increased level of skill in numeracy and computation .

**On successfully completing the level 7 module students will be able to:**

9.9 work competently and independently, be aware of their own strengths and understand when help is needed;

9.10 demonstrate a high level of capability in developing and evaluating logical arguments;

9.11 communicate arguments confidently with the effective and accurate conveyance of conclusions;

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 effective use of information technology skills such as Stan and Python, online resources (Moodle), internet communication;

* 1. communicate technical material competently;
	2. demonstrate an increased level of skill in numeracy and computation.
1. **A synopsis of the curriculum**

Bayes Theorem for density functions; Conjugate models; Predictive distribution; Bayes estimates; Sampling density functions; Gibbs and Metropolis-Hastings samplers; Stan and Python; Bayesian hierarchical models; Bayesian model choice; Objective priors; Exchangeability; Choice of priors; Applications of hierarchical models.

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

A.F.M. Smith and Bernardo, J.M. (1994). Bayesian Theory. Wiley.

A. Gelman, J.B. Carlin, H.S. Stern, D.B. Dunson, A. Vehtari and D.B. Rubin (2014). Bayesian Data Analysis. 3rd Edition, Chapman & Hall/CRC Texts in Statistical Science.

D. Gamerman and H.F. Lopes (2006). Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference. 2nd Edition, Taylor and Francis.

1. **Learning and teaching methods**

Total contact hours: 36

Private study hours: 114

Total study hours: 150

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

**Level 6 and 7**

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

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

Assessment 3: Exercises, requiring on average between 10 and 15 hours to complete 10%

Essay Assessment: Requiring on average 30 hours to complete 20%

Examination: 3 hours, open book computing exam 50%

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 6****Module learning outcome** | 8.1 | 8.2 | 8.3 | 8.4 | 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** | **X** |
| Lectures/Exercise classes | **X** | **X** | **X** | **X** | **X** | **X** | **X** |  | **X** | **X** | **X** | **X** |
| **Assessment method** |
| Examination | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Essay | **X** |  |  |  | **X** | **X** | **X** | **X** |  |  | **X** |  |
| Assessment 1 | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Assessment 2 | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Assessment 3 | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Level 7****Module learning outcome** | 8.1 | 8.2 | 8.3 | 8.4 | 9.9 | 9.10 | 9.11 | 9.12 | 9.13 | 9.14 | 9.15 | 9.16 |
| **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** | **X** | **X** | **X** |
| **Assessment method** |
| Examination | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Essay | **X** |  |  |  | **X** | **X** | **X** | **X** |  |  | **X** |  |
| Assessment 1 | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Assessment 2 | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| Assessment 3 | **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**

Statistics as a branch of mathematics is an international language with techniques developed and refined by statisticians across the globe. Mastery of the subject-specific learning outcomes, 8.1 to 8.4 (level 6) or 8.5 to 8.8 (level 7), 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.

**DIVISIONAL 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 delivery of revised version | Section revised | Impacts PLOs (Q6&7 cover sheet) |
| 11/04/22 | Major | Autumn 2022 | 7, 13, 14 |  |
|  |  |  |  |  |