1. **Title of the module**

MAST6360 (MA636) - Stochastic Processes

MAST8360 (MA836) - Stochastic Processes

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 6 (MAST6360), Level 7 (MAST8360)

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 6:**

For delivery to students completing Stage 1 before September 2016:

Pre-requisite: MA321 (Calculus and Mathematical Modelling), MA322 (Proofs and Numbers), and either MA323 (Matrices and Probability) and MA306 (Statistics) or MA319 (Probability and Inference for Actuarial Science) and MA326 (Matrices and Computing); MA552 (Analysis), MA553 (Linear Algebra) and either MA629 (Probability and Inference) or MA529 (Probability and Statistics for Actuarial Science 2); or their equivalents.

Co-requisite: None

For delivery to students completing Stage 1 after September 2016:

Pre-requisite: MAST4009 (Probability), MAST4011 (Statistics), MAST4006 (Mathematical Methods 1), MAST4007 (Mathematical Methods 2), either MAST4010 (Real Analysis 1) and MAST4004 (Linear Algebra) or MAST4005 (Linear Mathematics), and MAST5007 Mathematical Statistics; or their equivalents.

Co-requisite: None

**Level 7:**

Pre-requisite: Students are expected to have studied material equivalent to that covered in the modules above.

Co-requisite: None

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

For the level 6 module, BSc Actuarial Science, BSc Financial Mathematics, BSc Mathematics, BSc Mathematics and Statistics, BA Mathematics and Accounting & Finance (including programmes with a Year in Industry), BSc Mathematics with a Foundation Year, MMath Mathematics, MMathStat Mathematics and Statistics.

For the level 7 module, Postgraduate Diploma in Actuarial Science, MSc Statistics with Finance (including programme 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 stochastic modelling;

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: random walks, discrete and continuous time Markov chains, queues and branching processes;

8.3 apply key aspects of stochastic modelling in well-defined contexts, showing judgement in the selection and application of tools and techniques.

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

8.4 demonstrate systematic understanding of the concepts involved in stochastic modelling;

8.5 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: random walks, discrete and continuous time Markov chains, queues and branching processes;

8.6 apply a range of concepts and principles in stochastic modelling in loosely defined contexts, showing good judgement in the selection and application of tools and techniques.

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 and communicate technical material competently;

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 online resources (Moodle);

9.7 communicate technical material competently;

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

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

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

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

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

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

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

9.14 solve problems relating to qualitative and quantitative information;

9.15 make effective use of information technology skills such as online resources (Moodle);

9.16 communicate technical material effectively;

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

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

1. **A synopsis of the curriculum**

Introduction: Principles and examples of stochastic modelling, types of stochastic process, Markov property and Markov processes, short-term and long-run properties. Applications in various research areas.

Random walks: The simple random walk. Walk with two absorbing barriers. First–step decomposition technique. Probabilities of absorption. Duration of walk. Application of results to other simple random walks. General random walks. Applications.

Discrete time Markov chains: n–step transition probabilities. Chapman-Kolmogorov equations. Classification of states. Equilibrium and stationary distribution. Mean recurrence times. Simple estimation of transition probabilities. Time inhomogeneous chains. Elementary renewal theory. Simulations. Applications.

Continuous time Markov chains: Transition probability functions. Generator matrix. Kolmogorov forward and backward equations. Poisson process. Birth and death processes. Time inhomogeneous chains. Renewal processes. Applications.

Queues and branching processes: Properties of queues - arrivals, service time, length of the queue, waiting times, busy periods. The single-server queue and its stationary behaviour. Queues with several servers. Branching processes. Applications.

In addition, level 7 students will study more complex queuing systems and continuous-time branching processes.

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

Ross, S.M. (1996) Stochastic Processes. New York, Wiley.

Breuer, L. and Baum, D. (2005) An introduction to Queueing Theory and Matrix-Analytic Methods. Springer, Dordrecht.

Jones, P.W. and Smith, P. (2001) Stochastic Processes: An Introduction. London, Arnold.

Karlin, S., Taylor, H.M. (1998) A First Course in Stochastic Processes. 3rd Edition, Academic Press, London.

Ross, S.M. (1970) Applied Probability Models with Optimization Applications. Holden-Day, San Francisco.

Cox, D.R. and Miller, H.D. (1965) The Theory of Stochastic Processes. Chapman & Hall/CRC.

1. **Learning and teaching methods**

Total contact hours: 48

Private study hours: 102

Total study hours: 150

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

**Level 6**

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%

Examination 2 hours 80%

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

**Level 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%

Examination 2 hours 80%

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 6 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 | 9.9 |
| **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 class | **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** |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Level 7 Module learning outcome** | 8.4 | 8.5 | 8.6 | 9.10 | 9.11 | 9.12 | 9.13 | 9.14 | 9.15 | 9.16 | 9.17 | 9.18 |
| **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 class | **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 is an international language with techniques developed and refined by mathematicians 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.

**DIVISIONAL 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) |
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