# STAT683

## Introduction to Probability

S1 Day 2018

*Dept of Statistics*

## Contents

# General Information

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| Unit convenor and teaching staff<br>Unit Convenor<br>Georgy Sofronov<br>georgy.sofronov@mq.edu.au<br>Contact via georgy.sofronov@mq.edu.au<br>12 Wally's Walk (E7A), Room 535<br><br>Lecturer<br>Hassan Doosti<br>hassan.doosti@mq.edu.au<br>Contact via hassan.doosti@mq.edu.au<br>12 Wally's Walk (E7A), Room 534 |
| Credit points<br>4 |
| Prerequisites<br>Admission to MAppStat or GradCertAppStat or GradDipAppStat or MSc or MDataSc |
| Corequisites<br>STAT670 |
| Co-badged status<br>This unit is co-taught with STAT273. |
| Unit description<br>This unit consolidates and expands upon the material on probability introduced in STAT670. The emphasis is on the understanding of probability concepts and their application. Examples are taken from areas as diverse as biology, medicine, finance, sport, and the social and physical sciences. Topics include: the foundations of probability; probability models and their properties; some commonly used statistical distributions; relationships and association between variables; distribution of functions of random variables and sample statistics; approximations including the central limit theorem; and an introduction to the behaviour of random processes. Simulation is used to demonstrate many of these concepts. |

## Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

# Learning Outcomes

On successful completion of this unit, you will be able to:

- Be able to describe a probabilistic model for an experiment, calculate probability and conditional probability of an event. Have a deep understanding of the independence of events.
- Have a solid understanding of the difference between discrete and continuous random variables.
- For discrete or continuous random variables be able to calculate probabilities of events, their expected values and variances. Graph the probability distributions or probability density functions and the cumulative distribution functions. Using moment generating functions for finding of moments of random variables. Generate random numbers from distributions and use these numbers for solving probability problems.
- Have a deep knowledge of a bivariate probability distribution, joint, marginal, conditional probabilities and covariance. Have a solid understanding of a bivariate Normal distribution.
- Understand limit theorems: the Law of Large Numbers (LLN) and the Central Limit Theorem (CLT).
- Be able to generate random data. Be able to organise and summarise any random data. Determine whether a particular model fits random data.
- A solid understanding a Markov Chain (MC), a stationary distribution of MC. Interpretation of MCs with absorbing states.

# General Assessment Information

**Late submission**

In the case of the late submission of an assignment, if no special consideration has been granted, 10% of the earned mark will be deducted for each day that the assignment is late, up to a maximum of 50%. After 5 days, including weekends and public holidays, a mark of 0% will be awarded for the assignment.

NOTE: It is not the intention of this late penalty policy to cause a student to fail the unit when they have submitted their assignment no more than 5 days after the due date and they would have otherwise passed. In this case, if deductions for late assignments result in the final unit mark for a student being less than 50, when otherwise it would have been 50 or greater, the student's final mark will be exactly 50.

**Examination**

You are expected to present yourself for examination at the time and place designated in the University examination timetable, which will be available at https://timetables.mq.edu.au.

Only documented illness or unavoidable disruption may be used as reasons for not sitting an examination at the designated time. In these circumstances you may wish to consider applying for special consideration via ask.mq.edu.au.

Information about the Special Consideration Policy is available at:

https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policies/special-consideration

# Assessment Tasks

| Name | Weighting | Hurdle | Due |
|---|---|---|---|
| Test 1 | 10% | No | Week 4 lecture |
| Simulation project 1 | 10% | No | Week 7 |
| Test 2 | 10% | No | Week 10 lecture |
| Simulation project 2 | 10% | No | Week 12 |
| Final Examination | 60% | No | University Examination Period |

## Test 1

Due: **Week 4 lecture**
Weighting: **10%**

You are allowed to bring in one A4 page of handwritten notes, written on both sides. All necessary statistical tables and formulae will be provided.

An electronic calculator is essential. Non-programmable calculators with no text-retrieval capacity are allowed in the tests or exam.

On successful completion you will be able to:

- Be able to describe a probabilistic model for an experiment, calculate probability and conditional probability of an event. Have a deep understanding of the independence of events.
- Have a solid understanding of the difference between discrete and continuous random variables.
- For discrete or continuous random variables be able to calculate probabilities of events, their expected values and variances. Graph the probability distributions or probability density functions and the cumulative distribution functions. Using moment generating functions for finding of moments of random variables. Generate random numbers from distributions and use these numbers for solving probability problems.

## Simulation project 1

Due: **Week 7**
Weighting: **10%**

Students will be given one week to complete the simulation project.

On successful completion you will be able to:

- Be able to describe a probabilistic model for an experiment, calculate probability and conditional probability of an event. Have a deep understanding of the independence of events.
- Have a solid understanding of the difference between discrete and continuous random variables.
- For discrete or continuous random variables be able to calculate probabilities of events, their expected values and variances. Graph the probability distributions or probability density functions and the cumulative distribution functions. Using moment generating functions for finding of moments of random variables. Generate random numbers from distributions and use these numbers for solving probability problems.
- Understand limit theorems: the Law of Large Numbers (LLN) and the Central Limit Theorem (CLT).
- Be able to generate random data. Be able to organise and summarise any random data. Determine whether a particular model fits random data.

## Test 2

Due: **Week 10 lecture**
Weighting: **10%**

You are allowed to bring in one A4 page of handwritten notes, written on both sides. All necessary statistical tables and formulae will be provided. An electronic calculator is essential. Non-programmable calculators with no text-retrieval capacity are allowed in the tests or exam.

On successful completion you will be able to:

- Be able to describe a probabilistic model for an experiment, calculate probability and conditional probability of an event. Have a deep understanding of the independence of events.
- Have a solid understanding of the difference between discrete and continuous random variables.
- For discrete or continuous random variables be able to calculate probabilities of events,

their expected values and variances. Graph the probability distributions or probability density functions and the cumulative distribution functions. Using moment generating functions for finding of moments of random variables. Generate random numbers from distributions and use these numbers for solving probability problems.
- Understand limit theorems: the Law of Large Numbers (LLN) and the Central Limit Theorem (CLT).

## Simulation project 2

Due: **Week 12**
Weighting: **10%**

Students will be given one week to complete the simulation project.

On successful completion you will be able to:

- Be able to describe a probabilistic model for an experiment, calculate probability and conditional probability of an event. Have a deep understanding of the independence of events.
- Have a solid understanding of the difference between discrete and continuous random variables.
- For discrete or continuous random variables be able to calculate probabilities of events, their expected values and variances. Graph the probability distributions or probability density functions and the cumulative distribution functions. Using moment generating functions for finding of moments of random variables. Generate random numbers from distributions and use these numbers for solving probability problems.
- Have a deep knowledge of a bivariate probability distribution, joint, marginal, conditional probabilities and covariance. Have a solid understanding of a bivariate Normal distribution.
- Understand limit theorems: the Law of Large Numbers (LLN) and the Central Limit Theorem (CLT).
- Be able to generate random data. Be able to organise and summarise any random data. Determine whether a particular model fits random data.

## Final Examination

Due: **University Examination Period**
Weighting: **60%**

The examination will be of 3 hours duration with 10 minutes reading time.

For the Final examination you are allowed to bring in one A4 page of handwritten notes, written on both sides. All necessary statistical tables and formulae will be provided. An electronic calculator is essential and will be required. Non-programmable calculators with no text-retrieval capacity are allowed in the tests or exam.

If you receive special consideration for the final exam, a supplementary exam will be scheduled in the interval between the regular exam period and the start of the next session. By making a special consideration application for the final exam you are declaring yourself available for a resit during the supplementary examination period and will not be eligible for a second special consideration approval based on pre-existing commitments. Please ensure you are familiar with the Special Consideration Policy prior to submitting an application. You can check the supplementary exam information page on FSE101 in iLearn (bit.ly/FSESupp) for dates, and approved applicants will receive an individual notification one week prior to the exam with the exact date and time of their supplementary examination.

On successful completion you will be able to:

- Be able to describe a probabilistic model for an experiment, calculate probability and conditional probability of an event. Have a deep understanding of the independence of events.
- Have a solid understanding of the difference between discrete and continuous random variables.
- For discrete or continuous random variables be able to calculate probabilities of events, their expected values and variances. Graph the probability distributions or probability density functions and the cumulative distribution functions. Using moment generating functions for finding of moments of random variables. Generate random numbers from distributions and use these numbers for solving probability problems.
- Have a deep knowledge of a bivariate probability distribution, joint, marginal, conditional probabilities and covariance. Have a solid understanding of a bivariate Normal distribution.
- Understand limit theorems: the Law of Large Numbers (LLN) and the Central Limit Theorem (CLT).
- Be able to generate random data. Be able to organise and summarise any random data. Determine whether a particular model fits random data.
- A solid understanding a Markov Chain (MC), a stationary distribution of MC. Interpretation of MCs with absorbing states.

# Delivery and Resources

## Classes

STAT683 is delivered by lectures and tutorials.

The timetable for classes can be found on the University web site at:

https://timetables.mq.edu.au

# Required and Recommended Texts and/or Materials

There is no set textbook for this subject. Lecture notes will be available from iLearn at least the night before the lecture. Students should read the lecture notes before the lecture. All teaching materials will be available via iLearn.

References that may be useful

- Wackerly, D. D., Mendenhall, W., Scheaffer, R. L. Mathematical Statistics with Applications (4th,5th, 6th or 7th Editions)
- Ross, S. A First Course in Probability, Pearson (5th, 6th, 7th, 9th or 9th Editions)
- Ward, M. D. and Gundlach, E. (2016) Introduction to Probability, W. H. Freeman and Company
- Kinney, J.J. (1997) Probability - An Introduction with Statistical Applications, John Wiley and Sons
- Scheaffer R.L. (1994) Introduction to Probability and Its Applications, (2nd Edition) Duxbury Press
- Sincich,T., Levine, D.M., Stephan, D. (1999) Practical Statistics by Example using Microsoft Excel

**Technology Used and Required**

**iLearn**

There will be an iLearn site for this unit where weekly information, online discussions, lecture notes, iLectures, practice exercises and solutions will be posted.

Students are required to login to iLearn using their Student ID Number and myMQ Portal Password (note, information about how to get hold of your password is provided by the weblink https://ilearn.mq.edu.au). You can only access the material if you are enrolled in the unit.

**Software**

We will be using Microsoft Office for Windows (especially Excel), R and Wolfram Alpha, freely available online.

Audio/Video recordings of lectures will be available on iLearn soon after the lecture is delivered.

Course notes are available on iLearn before the lecture. Students should familiarise themselves with the notes before the lecture and bring a copy (in paper or electronic form) to class.

# Teaching and Learning Strategy

***Lectures***

Lectures begin in Week 1. STAT683 students should attend 3 hours per week. The lecture notes will be available on iLearn before the lecture.

***Tutorials***

Tutorials begin in Week 2 and are based on work from the previous week's lecture. The aim of tutorials is to apply techniques learnt in lectures to solve problems using a statistical package. The material is available on iLearn.

***Additional Exercises***

Additional exercises may also be made available on iLearn. It is expected that students will attempt all questions. The exercises will not be discussed during the tutorial, although some may be discussed during the lectures. A solution will be made available on the website.

# Unit Schedule

| WEEK | LECTURE TOPIC |
|---|---|
| W1 | Experiments, sample spaces, Probability Rules, Permutations and Combinations |
| W2 | Conditional Probability. Independence, Bayes' Theorem |
| W3 | Random Variables. Probability Functions, Discrete Probability Distributions, Cumulative Distribution functions, Expected value and Variance. Moments. |
| W4 | Important Discrete Distributions: Bernoulli, Binomial, Geometric and Poisson |
| W5 | Moment generating functions. More Discrete Distributions: Negative Binomial and Hypergeometric. |
| W6 | Introduction to Continuous random variables. Cumulative distribution function. |
| W7 | Continuous Distributions: Uniform, Exponential. |
| | **Mid-semester break** |
| W8 | Normal distribution. |
| W9 | Continuous Distributions: Gamma and Beta Distributions. Chebyshev's Theorem. |
| W10 | Sampling Distributions. |
| W11 | Joint Distributions: Discrete and Continuous cases. |
| W12 | Introduction to Markov Chains. States, Transition probabilities, State vectors, Equilibrium, Absorbing States |

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|---|---|
| **W13** | Revision |
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# Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy (***Note:*** *The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Undergraduate students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

## Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/student-conduct

## Results

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au.

## Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

### Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

## Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

## Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

## IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

# Graduate Capabilities

## Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

### Learning outcomes

- Be able to describe a probabilistic model for an experiment, calculate probability and conditional probability of an event. Have a deep understanding of the independence of events.

- Have a solid understanding of the difference between discrete and continuous random variables.
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## Assessment tasks

- Test 1
- Simulation project 1
- Test 2
- Simulation project 2
- Final Examination

# Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

## Learning outcomes

- Be able to describe a probabilistic model for an experiment, calculate probability and conditional probability of an event. Have a deep understanding of the independence of events.
- Have a solid understanding of the difference between discrete and continuous random

variables.
- For discrete or continuous random variables be able to calculate probabilities of events, their expected values and variances. Graph the probability distributions or probability density functions and the cumulative distribution functions. Using moment generating functions for finding of moments of random variables. Generate random numbers from distributions and use these numbers for solving probability problems.
- A solid understanding a Markov Chain (MC), a stationary distribution of MC. Interpretation of MCs with absorbing states.

### Assessment tasks

- Test 1
- Simulation project 1
- Test 2
- Simulation project 2
- Final Examination

## Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

### Learning outcome

- Be able to generate random data. Be able to organise and summarise any random data. Determine whether a particular model fits random data.

### Assessment tasks

- Simulation project 1
- Simulation project 2
- Final Examination