



# STAT821

## Multivariate Analysis

S2 Evening 2019

*Dept of Mathematics and Statistics*

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#### **Disclaimer**

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## General Information

Unit convenor and teaching staff

Unit Convenor

Jun Ma

[jun.ma@mq.edu.au](mailto:jun.ma@mq.edu.au)

Contact via email

12 Wally's Walk 526

See iLearn for consultation hours

Lecturer (3 weeks)

Andrew Locke

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Contact via Email

12 Wally's Walk level 6

See iLearn for consultation hours

Credit points

4

Prerequisites

((Admission to MAppStat or MSc or GradCertAppStat or GradDipAppStat or MActPrac or MDataSc) and (STAT806 or STAT810)) or ((admission to MLabQAMgt or GradDipLabQAMgt or GradCertLabQAMgt or MMarScMgt or MConsBiol or GradDipConsBiol or MScInnovation) and STAT830)

Corequisites

Co-badged status

STAT721

Unit description

This unit introduces methodologies and techniques for the exploration and analysis of multivariate data. Topics include graphical displays, discriminant analysis, principal components analysis, multivariate normal distribution, multivariate linear models, and cluster analysis.

## 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:

Understand the fundamental difference between univariate and multivariate analysis.

Know how to perform hypothesis testing (mainly the Hotelling T<sup>2</sup> test) using multivariate data.

Understand and be able to apply MANOVA.

Understand multivariate regression.

Know the theories of PCA and factor analysis, and be able to apply these methods to real data.

Understand likelihood based, as well as minimum expected cost based, discriminant analysis. Be able to apply these discriminant analysis methods to real data.

Understand the principles of classification tree and canonical analysis.

Know how to display multivariate data graphically using R.

Be able to use the R package for multivariate data analysis.

## General Assessment Information

**ASSIGNMENT SUBMISSION:** Assignment submission will be online through the iLearn page.

Submit assignments online via the appropriate assignment link on the iLearn page. A personalised cover sheet is not required with online submissions. Read the submission statement carefully before accepting it as there are substantial penalties for making a false declaration.

- Assignment submission is via iLearn. You should upload this as a single scanned PDF file.
- Please note the quick guide on how to upload your assignments provided on the iLearn page.
- Please make sure that each page in your uploaded assignment corresponds to only one A4 page (do not upload an A3 page worth of content as an A4 page in landscape). If you are using an app like Clear Scanner, please make sure that the photos you are using are clear and shadow-free.
- It is your responsibility to make sure your assignment submission is legible.
- If there are technical obstructions to your submitting online, please email us to let us know.

You may submit as often as required prior to the due date/time. Please note that each submission will completely replace any previous submissions. It is in your interests to make frequent submissions of your partially completed work as insurance against technical or other problems near the submission deadline.

**LATE SUBMISSION OF WORK:** All assignments or assessments must be submitted by the official due date and time. No marks will be given to late work unless an extension has been granted following a successful application for [Special Consideration](#). Please contact the unit

convenor for advice as soon as you become aware that you may have difficulty meeting any of the assignment deadlines. It is in your interests to make frequent submissions of your partially completed work. Note that later submissions completely replace any earlier submission, and so only the final submission made before the due date will be marked.

**FINAL EXAM POLICY:** examinations for individuals or groups of students. All students are expected to ensure that they are available until the end of the teaching semester, that is, the final day of the official examination period. The only excuse for not sitting an examination at the designated time is because of documented illness or unavoidable disruption. In these special circumstances, you may apply for special consideration via [ask.mq.edu.au](http://ask.mq.edu.au).

**SUPPLEMENTARY EXAMINATIONS:**

**IMPORTANT:** 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. If you apply for special consideration, you must give the supplementary examination priority over any other pre-existing commitments, as such commitments will not usually be considered an acceptable basis for a second application for special consideration. Please ensure you are familiar with the policy prior to submitting an application. You can check the supplementary exam information page on FSE101 in iLearn (<https://bit.ly/FSESupp>) for dates, and approved applicants will receive an individual notification sometime in the week prior to the exam with the exact date and time of their supplementary examination.

## Assessment Tasks

| Name                                | Weighting | Hurdle | Due                    |
|-------------------------------------|-----------|--------|------------------------|
| <a href="#">Assignment 1</a>        | 15%       | No     | 10pm on Aug 27, 2019   |
| <a href="#">Assignment 2</a>        | 15%       | No     | 10pm on Oct 2, 2019    |
| <a href="#">Assignment 3</a>        | 15%       | No     | 10pm on Oct 22, 2019   |
| <a href="#">Written Examination</a> | 55%       | No     | University Exam period |

### Assignment 1

Due: **10pm on Aug 27, 2019**

Weighting: **15%**

Assignment 1 will be due in week 5. Assignments may be handwritten or word-processed. Students will submit their assignments via a link on iLearn.

On successful completion you will be able to:

- Understand the fundamental difference between univariate and multivariate analysis.
- Know how to perform hypothesis testing (mainly the Hotelling T2 test) using multivariate data.

- Understand and be able to apply MANOVA.
- Know how to display multivariate data graphically using R.
- Be able to use the R package for multivariate data analysis.

## Assignment 2

Due: **10pm on Oct 2, 2019**

Weighting: **15%**

Assignment 2 will be due in week 8. Assignments may be handwritten or word-processed and students will submit their assignments via a link on iLearn.

On successful completion you will be able to:

- Understand multivariate regression.
- Know the theories of PCA and factor analysis, and be able to apply these methods to real data.
- Understand likelihood based, as well as minimum expected cost based, discriminant analysis. Be able to apply these discriminant analysis methods to real data.
- Understand the principles of classification tree and canonical analysis.
- Know how to display multivariate data graphically using R.
- Be able to use the R package for multivariate data analysis.

## Assignment 3

Due: **10pm on Oct 22, 2019**

Weighting: **15%**

Assignment 3 will be due in week 11. Assignments may be handwritten or word-processed and students will submit their assignments via a link on iLearn.

On successful completion you will be able to:

- Understand the fundamental difference between univariate and multivariate analysis.
- Know how to perform hypothesis testing (mainly the Hotelling T2 test) using multivariate data.
- Understand and be able to apply MANOVA.
- Understand multivariate regression.
- Know the theories of PCA and factor analysis, and be able to apply these methods to real data.
- Understand likelihood based, as well as minimum expected cost based, discriminant analysis. Be able to apply these discriminant analysis methods to real data.
- Understand the principles of classification tree and canonical analysis.

- Know how to display multivariate data graphically using R.
- Be able to use the R package for multivariate data analysis.

## Written Examination

Due: **University Exam period**

Weighting: **55%**

This is a written exam and it is to be scheduled in the university exam period. For this exam, students are allowed to bring into the exam room TWO A4 paper written on both sides; photocopies **are not** allowed. Only non-programmable calculators that do not have text retrieval capacity are allowed.

On successful completion you will be able to:

- Understand the fundamental difference between univariate and multivariate analysis.
- Know how to perform hypothesis testing (mainly the Hotelling T2 test) using multivariate data.
- Understand and be able to apply MANOVA.
- Understand multivariate regression.
- Know the theories of PCA and factor analysis, and be able to apply these methods to real data.
- Understand likelihood based, as well as minimum expected cost based, discriminant analysis. Be able to apply these discriminant analysis methods to real data.
- Understand the principles of classification tree and canonical analysis.

## Delivery and Resources

### Classes

You are required to attend a 2-hour lecture and a 1-hour SGTA each week. Please refer to the university timetable page for location details.

### Technologies used and required

We use the software package R in this Unit. R is becoming increasingly important for statisticians and other scientists. More information about R can be found at the web site <http://www.r-project.org/> and the package can be downloaded **free of charge** from there. R is very similar to the package S-PLUS and most of its codes will also work in S-Plus. From week 2, students will be given exercises each week covering materials from the lectures, and most exercises require using R.

### Recommended texts

**Prescribed textbook:** “**Applied Multivariate Statistical Analysis**” by Richard A. Johnson,

Dean W. Wichern (6<sup>th</sup> edition)

Students are expected to possess a copy of this textbook and are required to read certain book chapters each week. The following books may be used as other references for this unit:

- DILLON & GOLDSTEIN    Multivariate Analysis – Methods and applications(QA 278 .d55)
- FAHRMEIR & TUTZ        Multivariate statistical modelling based on generalized linear models  
(QA 278 .F34)
- FLURY, B                 A first course in multivariate statistics
- FLURY, B                 Multivariate statistics: A practical approach
- MORRISON, D             Multivariate statistical methods

## Unit Schedule

The following is a detailed list of the topics covered in this Unit, together with the planned delivery time. All lecture notes will be available on iLearn prior to the lecture.

| Week | Topic   |
|------|---|
| 1    | <ol style="list-style-type: none"><li>1. Introduction to multivariate analysis</li><li>2. Overview of matrix algebra</li></ol>              |
| 2    | <ol style="list-style-type: none"><li>1. Basic concepts of multivariate distributions</li><li>2. Sample statistics</li></ol>                |
| 3    | <ol style="list-style-type: none"><li>1. Multivariate sample statistics (cont.)</li><li>2. Some useful multivariate distributions</li></ol> |
| 4.   | <ol style="list-style-type: none"><li>1. Inferences: estimation and hypothesis testing</li></ol>  |
| 5.   | <ol style="list-style-type: none"><li>1. Inferences (cont.)</li></ol>   |
| 6.   | <ol style="list-style-type: none"><li>1. MANOVA</li></ol>   |
| 7.   | <ol style="list-style-type: none"><li>1. MANOVA (cont.)</li><li>2. Multivariate regression</li></ol>  |
| 8.   | <ol style="list-style-type: none"><li>1. Regression (cont.)</li><li>2. Principal component analysis (PCA)</li></ol>                         |

|     |  |
|-----|--|
| 9.  | 1. Factor analysis (FA)  |
| 11. | 1. Discriminant analysis and classification  |
| 12. | 1. A brief introduction to canonical correlation analysis<br>2. A brief introduction to cluster analysis |

## Policies and Procedures

Macquarie University policies and procedures are accessible from [Policy Central \(https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central\)](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 \(https://students.mq.edu.au/support/study/student-policy-gateway\)](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 \(https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central\)](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 published on platform other than [eStudent](#), (eg. iLearn, Coursera etc.) 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](http://ask.mq.edu.au) or if you are a Global MBA student contact [globalmba.support@mq.edu.au](mailto:globalmba.support@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](http://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](http://ask.mq.edu.au)

If you are a Global MBA student contact [globalmba.support@mq.edu.au](mailto:globalmba.support@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/](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

### PG - Discipline Knowledge and Skills

Our postgraduates will be able to demonstrate a significantly enhanced depth and breadth of knowledge, scholarly understanding, and specific subject content knowledge in their chosen fields.

This graduate capability is supported by:

### Learning outcomes

- Understand the fundamental difference between univariate and multivariate analysis.
- Know how to perform hypothesis testing (mainly the Hotelling T2 test) using multivariate

data.

- Understand and be able to apply MANOVA.
- Understand multivariate regression.
- Know the theories of PCA and factor analysis, and be able to apply these methods to real data.
- Understand likelihood based, as well as minimum expected cost based, discriminant analysis. Be able to apply these discriminant analysis methods to real data.
- Understand the principles of classification tree and canonical analysis.
- Know how to display multivariate data graphically using R.
- Be able to use the R package for multivariate data analysis.

## Assessment tasks

- Assignment 1
- Assignment 2
- Assignment 3
- Written Examination

## PG - Critical, Analytical and Integrative Thinking

Our postgraduates will be capable of utilising and reflecting on prior knowledge and experience, of applying higher level critical thinking skills, and of integrating and synthesising learning and knowledge from a range of sources and environments. A characteristic of this form of thinking is the generation of new, professionally oriented knowledge through personal or group-based critique of practice and theory.

This graduate capability is supported by:

## Learning outcomes

- Understand the fundamental difference between univariate and multivariate analysis.
- Know how to perform hypothesis testing (mainly the Hotelling T2 test) using multivariate data.
- Understand and be able to apply MANOVA.
- Understand multivariate regression.
- Know the theories of PCA and factor analysis, and be able to apply these methods to real data.
- Understand likelihood based, as well as minimum expected cost based, discriminant analysis. Be able to apply these discriminant analysis methods to real data.
- Understand the principles of classification tree and canonical analysis.
- Know how to display multivariate data graphically using R.

## Assessment tasks

- Assignment 1
- Assignment 2
- Assignment 3
- Written Examination

## PG - Research and Problem Solving Capability

Our postgraduates will be capable of systematic enquiry; able to use research skills to create new knowledge that can be applied to real world issues, or contribute to a field of study or practice to enhance society. They will be capable of creative questioning, problem finding and problem solving.

This graduate capability is supported by:

### Learning outcomes

- Understand the fundamental difference between univariate and multivariate analysis.
- Know how to perform hypothesis testing (mainly the Hotelling T2 test) using multivariate data.
- Understand and be able to apply MANOVA.
- Understand multivariate regression.
- Know the theories of PCA and factor analysis, and be able to apply these methods to real data.
- Understand likelihood based, as well as minimum expected cost based, discriminant analysis. Be able to apply these discriminant analysis methods to real data.
- Understand the principles of classification tree and canonical analysis.
- Know how to display multivariate data graphically using R.
- Be able to use the R package for multivariate data analysis.

## Assessment tasks

- Assignment 1
- Assignment 2
- Assignment 3

## PG - Effective Communication

Our postgraduates will be able to communicate effectively and convey their views to different social, cultural, and professional audiences. They will be able to use a variety of technologically supported media to communicate with empathy using a range of written, spoken or visual formats.

This graduate capability is supported by:

## Learning outcomes

- Know how to perform hypothesis testing (mainly the Hotelling T<sup>2</sup> test) using multivariate data.
- Understand and be able to apply MANOVA.
- Understand multivariate regression.
- Know the theories of PCA and factor analysis, and be able to apply these methods to real data.
- Know how to display multivariate data graphically using R.
- Be able to use the R package for multivariate data analysis.

## Assessment tasks

- Assignment 1
- Assignment 2
- Assignment 3
- Written Examination