



# MATH339

## Real and Functional Analysis

S2 Day 2019

*Dept of Mathematics and Statistics*

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#### **Disclaimer**

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## General Information

Unit convenor and teaching staff

Lecturer - Unit convenor

Ji Li

[ji.li@mq.edu.au](mailto:ji.li@mq.edu.au)

Contact via e-mail

12 Wally's Walk, Room 729

Thursday 2 - 3 pm or by appointment

Lecturer

Anh Bui

[the.bui@mq.edu.au](mailto:the.bui@mq.edu.au)

Contact via e-mail

12 Wally's Walk, Room 606

Monday 2 - 3pm or by appointment

Ji Li

[ji.li@mq.edu.au](mailto:ji.li@mq.edu.au)

Credit points

3

Prerequisites

(MATH235 and MATH236) or MATH331 or MATH332 or MATH335 or MATH336

Corequisites

Co-badged status

Unit description

This unit is concerned with a review of the limiting processes of real analysis and an introduction to functional analysis. Through the discussion of such abstract notions as metric spaces, normed vector spaces and inner product spaces, we can appreciate an elegant and powerful combination of ideas from analysis and linear algebra.

## 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:

1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
3. construct sustained logical, clearly presented and justified mathematical arguments incorporating deductive reasoning.
4. formulate and model practical and abstract problems in mathematical terms using a variety of methods drawn from analysis and functional analysis.
5. apply mathematical principles, concepts, techniques and technology efficiently to solve practical and abstract problems across a range of areas in analysis and functional analysis.
6. appropriately interpret mathematical information communicated in wide range of forms.
7. present mathematical ideas, information, reasoning and conclusions in forms tailored to the needs of diverse audiences.
9. work effectively, responsibly and safely in individual context.
10. preparing students for further studies in the areas of advanced analysis and applied mathematics.

## General Assessment Information

**HURDLES:** This unit has no hurdle requirements.

**ATTENDANCE and PARTICIPATION:** Please contact the unit convenor as soon as possible if you have difficulty attending and participating in any classes. There may be alternatives available to make up the work. If there are circumstances that mean you miss a class, you can apply for a [Special Consideration](#).

**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>	10%	No	Week 5
<a href="#">Assignment 2</a>	10%	No	Week 8
<a href="#">Test</a>	20%	No	Friday 25 Oct
<a href="#">Assignment 3</a>	10%	No	Week 12

Name	Weighting	Hurdle	Due
<u>Final exam</u>	50%	No	Formal Exam Period

## Assignment 1

Due: **Week 5**

Weighting: **10%**

Solve problems

On successful completion you will be able to:

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
- 3. construct sustained logical, clearly presented and justified mathematical arguments incorporating deductive reasoning.
- 4. formulate and model practical and abstract problems in mathematical terms using a variety of methods drawn from analysis and functional analysis.
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- 6. appropriately interpret mathematical information communicated in wide range of forms.
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- 10. preparing students for further studies in the areas of advanced analysis and applied mathematics.

## Assignment 2

Due: **Week 8**

Weighting: **10%**

Solve problems

On successful completion you will be able to:

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
- 3. construct sustained logical, clearly presented and justified mathematical arguments incorporating deductive reasoning.
- 4. formulate and model practical and abstract problems in mathematical terms using a variety of methods drawn from analysis and functional analysis.
- 5. apply mathematical principles, concepts, techniques and technology efficiently to solve practical and abstract problems across a range of areas in analysis and functional analysis.
- 6. appropriately interpret mathematical information communicated in wide range of forms.
- 7. present mathematical ideas, information, reasoning and conclusions in forms tailored to the needs of diverse audiences.
- 9. work effectively, responsibly and safely in individual context.
- 10. preparing students for further studies in the areas of advanced analysis and applied mathematics.

## Test

Due: **Friday 25 Oct**

Weighting: **20%**

50 Minute Class test

On successful completion you will be able to:

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
- 3. construct sustained logical, clearly presented and justified mathematical arguments incorporating deductive reasoning.
- 4. formulate and model practical and abstract problems in mathematical terms using a

variety of methods drawn from analysis and functional analysis.

- 5. apply mathematical principles, concepts, techniques and technology efficiently to solve practical and abstract problems across a range of areas in analysis and functional analysis.
- 6. appropriately interpret mathematical information communicated in wide range of forms.
- 7. present mathematical ideas, information, reasoning and conclusions in forms tailored to the needs of diverse audiences.
- 9. work effectively, responsibly and safely in individual context.
- 10. preparing students for further studies in the areas of advanced analysis and applied mathematics.

## Assignment 3

Due: **Week 12**

Weighting: **10%**

Solve problems

On successful completion you will be able to:

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
- 3. construct sustained logical, clearly presented and justified mathematical arguments incorporating deductive reasoning.
- 4. formulate and model practical and abstract problems in mathematical terms using a variety of methods drawn from analysis and functional analysis.
- 5. apply mathematical principles, concepts, techniques and technology efficiently to solve practical and abstract problems across a range of areas in analysis and functional analysis.
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- 7. present mathematical ideas, information, reasoning and conclusions in forms tailored to the needs of diverse audiences.
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## Final exam

Due: **Formal Exam Period**

Weighting: **50%**

The final examination is two hours (plus 10 min reading time) in duration.

On successful completion you will be able to:

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
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## Delivery and Resources

**Lecture time:** Wed 2 pm - 4 pm (23 WW, room 205) and Fri 2 pm - 4 pm (12 Second Way, room 407);

Tutorial time is included in the lecture time above.

Lecture notes will be available on the web; student can also use

Chen: Fundamentals of Analysis



Chen: Linear Functional Analysis

The following texts are suggested for reference only, and it is not essential to own copies:

Lay: Analysis with an introduction to proof

Gordon: Real Analysis, A First course

Burkill: A First Course in Mathematical Analysis

Burkill and Burkill: A Second Course in Mathematical Analysis

Young: An Introduction to Hilbert Space

## Unit Schedule

- Week 1: The number system, completeness and consequences.
- Week 1: Countability, cardinal numbers, Cantor-Bernstein-Schröder theorem.
- Week 2: Sequences and limits, subsequences, general principle of convergence.
- Week 3 and 4: Series, real series, complex series, power series.
- Week 4: Functions and continuity.
- Week 5 and 6: Derivatives and Integrations
- Week 7: Further limits - Uniform Convergence

Mid Session Break (2 weeks)

- Week 8: Metric spaces, open and closed sets, limits and continuity.
- Week 9: Connectedness, completeness, compactness, continuous functions with compact domains.
- Week 10: Normed vector spaces, Banach spaces.
- Week 11: Inner product spaces, Hilbert spaces.
- Week 11: Orthogonal expansions, orthonormal systems, orthonormal bases.
- Week 12: Isomorphism of Hilbert spaces, splitting up a Hilbert spaces
- Week 12: Linear functionals, dual space.
- Week 13: Revision

## 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](http://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central) (<http://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

### Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

### Learning outcomes

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
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- 9. work effectively, responsibly and safely in individual context.

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## **Assessment tasks**

- Assignment 1
- Assignment 2
- Test
- Assignment 3
- Final exam

## **Capable of Professional and Personal Judgement and Initiative**

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

## **Learning outcomes**

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
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## Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

## Learning outcomes

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
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## 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

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
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## 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

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
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## 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 outcomes

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
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## Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

## Learning outcomes

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
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## Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

## Learning outcomes

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
- 2. demonstrate an understanding of the breadth of mathematics, the multi-disciplinary role of mathematics and the way it contributes the development in other related fields of study.
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## Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

## Learning outcomes

- 1. demonstrate a well- developed knowledge of the principles, concepts and techniques of a broad range of areas in analysis and applied mathematics, with significant depth in analysis and functional analysis.
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