

MA4J0-15 Advanced Real Analysis

26/27

Department

Warwick Mathematics Institute

Level

Undergraduate Level 4

Module leader

Jose Rodrigo

Credit value

15

Module duration

10 weeks

Assessment

Multiple

Study location

University of Warwick main campus, Coventry

Description

Introductory description

The module builds upon modules from the second and third year like Metric Spaces, Measure Theory and Functional Analysis I to present the fundamental tools in Harmonic Analysis and some applications, primarily in Partial Differential Equations.

[Module web page](#)

Module aims

Some of the main aims include:

Setting up a rigorous calculus of rough objects, such as distributions.

Studying the boundedness of singular integrals and their applications.

Understanding the scaling properties of inequalities.

Defining Sobolev spaces using the Fourier Transform and the connections between the decay of the Fourier Transform and the regularity of functions.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

Distributions on Euclidean space.
Tempered distributions and Fourier transforms.
Singular integral operators and Calderon-Zygmund theory.
Theory of Fourier multipliers.
Littlewood-Paley theory.

Learning outcomes

By the end of the module, students should be able to:

- Definition of Sobolev spaces using the Fourier Transform and the connections between the decay of the Fourier Transform and the regularity of functions.
- Connection between the boundedness of singular integrals and the existence of solutions for some partial differential equation.
- Connections between singular integrals and the summation of Fourier series.
- Understanding the scaling properties of inequalities.
- Reinforce analytical thinking developed in previous courses.

Indicative reading list

[Reading lists can be found in Talis](#)

Subject specific skills

1. Understand the calculus of distributions. In particular, see how one can differentiate non-smooth objects and solve differential equations without smooth (or even differentiable functions).
2. How to properly understand point 1 above within the context of duality.
3. Study boundedness of operators with singular kernels. In particular, one would like to understand Calderon-Zygmund decomposition in n dimensions (the one-dimensional case having been studied in term in Fourier analysis).
4. Analyse frequency decompositions into dyadic blocks. This is done within the context of Littlewood-Paley theory.
5. Analyse Fourier multiplier operators.
6. Analyse Sobolev spaces, in particular with degree of differentiation being a real number (the case of integer-derivative Sobolev spaces is covered in other modules).

Transferable skills

1. Understand how to apply rules of calculus in the most general context and get a new perspective on this.
 2. Obtain 'big picture' thinking from 1
 3. Improve the writing of rigorous proofs.
 4. Prepare students for a PhD in mathematical analysis or a related field.
-

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Tutorials	9 sessions of 1 hour (6%)
Private study	111 hours (74%)
Total	150 hours

Private study description

Office hours, private study, preparation for lectures and exams, assignment sheets.

Costs

No further costs have been identified for this module.

Assessment

You do not need to pass all assessment components to pass the module.

Students can register for this module without taking any assessment.

Assessment group B1

	Weighting	Study time	Eligible for self-certification
Centrally-timetabled examination (On-campus)	100%		No
Answerbook Gold (24 page)			

Assessment group R

	Weighting	Study time	Eligible for self-certification
In-person Examination - Resit	100%		No
Answerbook Gold (24 page)			

Feedback on assessment

Marked coursework and oral exam feedback.

[Past exam papers for MA4J0](#)

Availability

Courses

This module is Optional for:

- TMAA-G1PE Master of Advanced Study in Mathematical Sciences
 - Year 1 of G1PE Master of Advanced Study in Mathematical Sciences
 - Year 1 of G1PE Master of Advanced Study in Mathematical Sciences
- Year 1 of TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics
- TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
 - Year 1 of G1PC Mathematics (Diploma plus MSc)
 - Year 2 of G1PC Mathematics (Diploma plus MSc)

This module is Core option list F for:

- Year 4 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Option list A for:

- TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
 - Year 1 of G1PD Interdisciplinary Mathematics (Diploma plus MSc)
 - Year 2 of G1PD Interdisciplinary Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1P0 Postgraduate Taught Mathematics
- Year 1 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- Year 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)

This module is Option list B for:

- TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
 - Year 1 of G1PD Interdisciplinary Mathematics (Diploma plus MSc)
 - Year 2 of G1PD Interdisciplinary Mathematics (Diploma plus MSc)
- Year 1 of TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- Year 4 of UCSA-G4G3 Undergraduate Discrete Mathematics
- Year 5 of UCSA-G4G4 Undergraduate Discrete Mathematics (with Intercalated Year)

This module is Option list C for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
 - Year 3 of G105 Mathematics (MMath) with Intercalated Year
 - Year 4 of G105 Mathematics (MMath) with Intercalated Year
 - Year 5 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G103 Undergraduate Mathematics (MMath)
 - Year 3 of G103 Mathematics (MMath)
 - Year 4 of G103 Mathematics (MMath)
- Year 4 of UMAA-G107 Undergraduate Mathematics (MMath) with Study Abroad
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
 - Year 3 of G106 Mathematics (MMath) with Study in Europe
 - Year 4 of G106 Mathematics (MMath) with Study in Europe

This module is Option list E for:

- Year 5 of USTA-G301 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics (with Intercalated