

MA4M2-15 Mathematics of inverse problems

26/27

Department

Warwick Mathematics Institute

Level

Undergraduate Level 4

Module leader

Marie-Therese Wolfram

Credit value

15

Module duration

10 weeks

Assessment

100% exam

Study location

University of Warwick main campus, Coventry

Description

Introductory description

Inverse problems play an increasingly important role for modern data oriented applications. Classical examples are medical imaging and tomography where one attempts to reconstruct the internal structure from transmission data.

Using the theory of partial differential equations it is possible to map the unknown internal structure to the observed data. The task of inverting this map is called 'Inverse Problem'.

We will study the mathematical theory that underpins the construction of the forward operator and devise regularisation techniques that will result in well posed inverse problems.

Module aims

- Students will be able to identify inverse problems in applications like acoustics.
- They will become aware of the connections between the theory of partial differential equations and parameter estimation problems.
- They will be able to devise regularisations for simple inverse problems so that the regularised problem admits solutions

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.

- Review of Functional Analysis and PDE theory
- Modelling of simple physical systems, Radon transform
- Loss functions and the direct method
- Regularisation: Tikhonov and Total Variation
- Convergence of solutions for vanishing noise

Learning outcomes

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

- Understand the difference between forward problems and inverse problem
- Derive the loss functional for specific applications
- Apply the direct method to establish the existence of solutions of regularised inverse problems

Interdisciplinary

Inverse problems typically involve physical models. It is critical that students understand the origins of the inverse problems and the implications for the accuracy that the solutions of inverse problems can achieve.

Subject specific skills

Ability to use methods from pde theory

Ability to model simple physical systems

Ability differentiate between noise and bias

Transferable skills

Ability to interpret data. Ability to translate scientific ideas into mathematical language. Ability to think creatively because inverse problems admit many different solutions.

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Private study	117 hours (80%)
Total	147 hours

Private study description

Homework problems.

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group B

Assessment component	Weighting	Study time	Eligible for self-certification
Centrally-timetabled examination (On-campus) Standard 3 hour written exam.	100%	3 hours	No

- Answerbook Gold (24 page)

Reassessment component is the same

Feedback on assessment

Written feedback on the outcome of the exam.

[Past exam papers for MA4M2](#)

Availability

Courses

This module is Optional for:

- Year 1 of TMAA-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:

- Year 2 of TMAA-G1PD Postgraduate Taught Interdisciplinary Mathematics (Diploma plus MSc)
- Year 4 of UPA-XA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
- Year 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)

This module is Option list B for:

- Year 2 of TMAA-G1PD Postgraduate Taught Interdisciplinary 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