

MA3H5-15 Manifolds

26/27

Department

Warwick Mathematics Institute

Level

Undergraduate Level 3

Module leader

Dmitriy Rumynin

Credit value

15

Module duration

10 weeks

Assessment

Multiple

Study location

University of Warwick main campus, Coventry

Description

Introductory description

Smooth manifolds are generalisations of the notion of curves and surfaces $\mathbb{R}^3$ and provide a rigorous mathematical concept of space as well as a natural setting for analysis. They form a fundamental part of modern mathematics and are used widely in pure and applied subjects such as differential geometry, general relativity and partial differential equations. Almost all the manifolds discussed in the course will be assumed to have a smooth structure. This allows us to perform the standard operations of differentiation in a very general context. We will begin by discussing manifolds embedded in euclidean space, $\mathbb{R}^n$. We develop some of the basic notions such as smooth maps and tangent spaces in this context. We go on to describe the notion of an abstract manifold, and explain how these concepts generalise. We discuss basic concepts of orientability, differential forms and integration. Time permitting, we will aim to give a proof of the general form of Stokes's Theorem. We may briefly touch on subjects such as riemannian manifolds and Lie groups. These are the subject of dedicated courses in the 4th year.

[Module web page](#)

Module aims

To introduce notion of an abstract smooth manifold and to develop students geometric intuition of manifolds together with rigorous analysis.

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.

Manifolds in euclidean space, smooth maps, tangent spaces, immersions and submersions, tangent and normal bundles, orientations, abstract manifolds, vector bundles, partitions of unity, differential forms, integration, Stokes's theorem.

Learning outcomes

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

- Understand one important ideas that underlie the theory of differentiable manifolds and to develop skills in manipulation of differentiable objects.
- Prove that various sets are manifolds by explicit construction of charts.
- Construct manifolds using the implicit function theorem.
- Understand the definition of tangent space of a manifold, and perform various constructions related to vector fields.
- Manipulate differential forms and understand Stokes theorem.

Indicative reading list

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

Subject specific skills

The course will expose students to a wide range of ideas in a subject of broad applicability in mathematics and the sciences. The students will learn to familiarise themselves with abstract concepts, and to relate them to physical intuition.

Transferable skills

They will learn to follow complex reasoning, to construct logical arguments, to think independently, and to develop research skills.

Study

Study time

Type	Required
Lectures	30 sessions of 1 hour (20%)
Seminars	10 sessions of 1 hour (7%)
Private study	110 hours (73%)
Total	150 hours

Private study description

110 hours: private study, assessed work, revision for exam

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

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

Reassessment component is the same

Assessment group R

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

Feedback on assessment

support classes, work returned after marking, exam feedback.

[Past exam papers for MA3H5](#)

Availability

Courses

This module is Optional for:

- 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)
- Year 3 of UCSA-G4G1 Undergraduate Discrete Mathematics
- UCSA-G4G3 Undergraduate Discrete Mathematics
 - Year 3 of G4G1 Discrete Mathematics
 - Year 3 of G4G3 Discrete Mathematics
- Year 4 of UCSA-G4G4 Undergraduate Discrete Mathematics (with Intercalated Year)
- Year 4 of UCSA-G4G2 Undergraduate Discrete Mathematics with Intercalated Year

This module is Core option list A for:

- Year 4 of UMAA-GV18 Undergraduate Mathematics and Philosophy with Intercalated Year

This module is Core option list B for:

- Year 3 of UMAA-GV17 Undergraduate Mathematics and Philosophy
- Year 3 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Core option list C for:

- Year 3 of UMAA-GV17 Undergraduate Mathematics and Philosophy
- Year 3 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Core option list D for:

- Year 4 of UMAA-GV18 Undergraduate Mathematics and Philosophy with Intercalated Year
- Year 4 of UMAA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

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)
- 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
- Year 3 of UMAA-G100 Undergraduate Mathematics (BSc)
- UMAA-G103 Undergraduate Mathematics (MMath)
 - Year 3 of G100 Mathematics
 - 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
- Year 3 of UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
 - Year 3 of GF13 Mathematics and Physics
 - Year 3 of FG31 Mathematics and Physics (MMathPhys)
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)
- Year 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 5 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
- Year 4 of UMAA-G101 Undergraduate Mathematics with Intercalated Year

This module is Option list B for:

- Year 1 of TMAA-G1PE Master of Advanced Study in Mathematical Sciences
- Year 3 of USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
- Year 4 of USTA-GG17 Undergraduate Mathematics and Statistics (with Intercalated Year)

This module is Option list C for:

- Year 3 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)

This module is Option list E for:

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

- Year 3 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
- Year 4 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
- Year 5 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)