

# MA259-12 Multivariable Calculus

**21/22**

**Department**

Warwick Mathematics Institute

**Level**

Undergraduate Level 2

**Module leader**

Mario Micallef

**Credit value**

12

**Module duration**

10 weeks

**Assessment**

Multiple

**Study location**

University of Warwick main campus, Coventry

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## Description

### Introductory description

N/A

[Module web page](#)

### Module aims

To extend the analysis of one variable from the first year to the multivariable context.

### 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.

- Continuous Vector-Valued Functions
- Some Linear Algebra
- Differentiable Functions
- Inverse Function Theorem and Implicit Function Theorem
- Vector Fields, Green's Theorem in the Plane and the Divergence Theorem in  $\mathbb{R}^3$
- Maxima, minima and saddles

## Learning outcomes

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

- Demonstrate understanding of the basic concepts, theorems and calculations of multivariate analysis.
- Demonstrate understanding of the Implicit and Inverse Function Theorems and their applications.
- Demonstrate understanding of vector fields and Green's Theorem and the Divergence Theorem.
- Demonstrate the ability to analyse and classify critical points using Taylor expansions.

## Indicative reading list

1. R. Abraham, J. E. Marsden, T. Ratiu. Manifolds, Tensor Analysis, and Applications. Springer, second edition, 1988.
2. T. M. Apostol. Mathematical Analysis. Addison-Wesley Publishing Co., Reading, Mass.-London-Don Mills, Ont., second edition, 1974.
3. R. Coleman. Calculus on normed vector spaces, Springer 2012. [available online via Warwick's library]
4. J. J. Duistermaat, J. A. C. Kolk. Multidimensional Real Analysis I : Differentiation, CUP, 2004 [available online via Warwick's library]
5. T. W. Körner. A Companion to Analysis: A Second First and First Second Course in Analysis, volume 62 of Graduate Studies in Mathematics. American Mathematical Society, Providence, RI, 2004.
6. J. E. Marsden and A. Tromba. Vector Calculus. Macmillan Higher Education, sixth edition, 2011.
7. J. R. Munkres. Analysis on Manifolds. Addison-Wesley Publishing Company, Advanced Book Program, Redwood City, CA, 1991.
8. W. Rudin. Principles of Mathematical Analysis. International Series in Pure and Applied Mathematics. McGraw-Hill Book Co., New York-Auckland-Düsseldorf, third edition, 1976.
9. M. Spivak. Calculus on Manifolds. A Modern Approach to Classical Theorems of Advanced Calculus. W. A. Benjamin, Inc., New York-Amsterdam, 1965.

## Subject specific skills

Students will gain knowledge of definitions, theorems and calculations in

- Continuous vector-valued functions
- Differentiable functions
- Inverse and Implicit Function Theorems
- Vector fields
- Maxima, minima and saddles

## Transferable skills

Students will acquire key reasoning and problem solving skills which will empower them to

address new problems with confidence.

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## Study

### Study time

Type	Required
Lectures	30 sessions of 1 hour (25%)
Seminars	5 sessions of 1 hour (4%)
Other activity	10 hours (8%)
Private study	75 hours (62%)
Total	120 hours

### Private study description

85 self-working: reviewing lectured material and accompanying supplementary materials; working on both summative and formative coursework; revising for exams.

### Other activity description

Collaborative project

## Costs

No further costs have been identified for this module.

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## Assessment

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

### Assessment group D2

	Weighting	Study time
Assignments	15%	
Project	10%	
Examination	75%	

- Answerbook Pink (12 page)

### Assessment group R

	Weighting	Study time
In-person Examination - Resit	100%	
<ul style="list-style-type: none"> <li>• Answerbook Pink (12 page)</li> </ul>		

## Assessment group S

	Weighting	Study time
Assignments	15%	
In-person Examination	85%	
<ul style="list-style-type: none"> <li>• Answerbook Pink (12 page)</li> </ul>		

## Feedback on assessment

Marked homework (both assessed and formative) is returned and discussed in smaller classes. Exam feedback is given.

[Past exam papers for MA259](#)

## Availability

## Courses

This module is Core for:

- Year 2 of UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)
- UMAA-G100 Undergraduate Mathematics (BSc)
  - Year 2 of G100 Mathematics
  - Year 2 of G100 Mathematics
  - Year 2 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
  - Year 2 of G100 Mathematics
  - Year 2 of G103 Mathematics (MMath)
  - Year 2 of G103 Mathematics (MMath)
- Year 2 of UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
- Year 2 of UMAA-G1NC Undergraduate Mathematics and Business Studies
- Year 2 of UMAA-G1N2 Undergraduate Mathematics and Business Studies (with Intercalated Year)
- Year 2 of UMAA-GL11 Undergraduate Mathematics and Economics
- Year 2 of UECA-GL12 Undergraduate Mathematics and Economics (with Intercalated Year)
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
  - Year 2 of GF13 Mathematics and Physics

- Year 2 of GF13 Mathematics and Physics
- UPPA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
  - Year 2 of FG31 Mathematics and Physics (MMathPhys)
  - Year 2 of FG31 Mathematics and Physics (MMathPhys)
- Year 2 of UPPA-G101 Undergraduate Mathematics with Intercolated Year

This module is Optional for:

- USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics
  - Year 3 of G300 Mathematics, Operational Research, Statistics and Economics
  - Year 4 of G300 Mathematics, Operational Research, Statistics and Economics
- Year 2 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
  - Year 2 of GG14 Mathematics and Statistics
  - Year 2 of GG14 Mathematics and Statistics

This module is Core option list A for:

- UPPA-GV17 Undergraduate Mathematics and Philosophy
  - Year 2 of GV17 Mathematics and Philosophy
  - Year 2 of GV17 Mathematics and Philosophy
  - Year 2 of GV17 Mathematics and Philosophy
- Year 2 of UPPA-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Option list A for:

- Year 2 of USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics
- USTA-Y602 Undergraduate Mathematics, Operational Research, Statistics and Economics
  - Year 2 of Y602 Mathematics, Operational Research, Stats, Economics
  - Year 2 of Y602 Mathematics, Operational Research, Stats, Economics

This module is Option list B for:

- UCSA-G4G1 Undergraduate Discrete Mathematics
  - Year 2 of G4G1 Discrete Mathematics
  - Year 2 of G4G1 Discrete Mathematics
- Year 2 of UCSA-G4G3 Undergraduate Discrete Mathematics
- Year 3 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 4 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercolated Year)
- USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
  - Year 3 of GG14 Mathematics and Statistics
  - Year 3 of GG14 Mathematics and Statistics
- Year 4 of USTA-GG17 Undergraduate Mathematics and Statistics (with Intercolated Year)
- USTA-Y602 Undergraduate Mathematics, Operational Research, Statistics and Economics

- Year 3 of Y602 Mathematics, Operational Research, Stats, Economics
- Year 3 of Y602 Mathematics, Operational Research, Stats, Economics

This module is Option list E for:

- Year 3 of USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics
- 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)