# MA3K0-15 High-Dimensional Probability

## 22/23

**Department**
> Warwick Mathematics Institute

**Level**
> Undergraduate Level 3

**Module leader**
> Stefan Adams

**Credit value**
> 15

**Assessment**
> Multiple

**Study location**
> University of Warwick main campus, Coventry

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# Description

## Introductory description

N/A

[Module web page](Module web page)

## Module aims

- Concentration of measure problem in high dimensions
- Three basic concentration inequalities
- Application of basic variational principles
- Concentration of the norm
- Dependency structures
- Introduction to random matrices

## 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.

- Preliminaries on Random Variables (limit theorems, classical inequalities, Gaussian models,

Monte Carlo)
- Basic Information theory (entropy; Kull-Back Leibler information divergence)
- Concentrations of Sums of Independent Random Variables
- Random Vectors in High Dimensions
- Random Matrices
- Concentration with Dependency structures
- Deviations of Random Matrices and Geometric Consequences
- Graphical models and deep learning

## Learning outcomes

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

- Understand the concentration of measure problem in high dimensions
- Be able to distinguish three basic concentration inequalities
- Be able to distinguish between concentration for independent families as well as for various dependency structures
- Understanding of basic concentrations of the norm
- Familiar with random matrices (main properties)
- Be familiar with some application of graphical models
- Be able to understand basic variational problems

## Indicative reading list

We won't follow a particular book and will provide lecture notes. The course is based on the following three books where the majority is taken from [1]:
[1] Roman Vershynin, High-Dimensional Probability: An Introduction with Applications in Data Science, Cambridge Series in Statistical and Probabilistic Mathematics, (2018).
[2] Kevin P. Murphy, Machine Learning - A Probabilistic Perspective, MIT Press (2012).
[3] Simon Rogers and Mark Girolami, A first course in Machine Learning, CRC Press (2017).
[4] Alex Kulesza and Ben Taskar, Determinantal point processes for machine learning, Lecture Notes (2013).

## Subject specific skills

- Understanding that the concentration of measure problem requires analytical expertise as well as some basic probability
- Be able to distinguish three basic concentration inequalities
- Be able to distinguish between concentration for independent families as well as for various dependency structures
- Understanding of basic concentrations of the norm
- Familiar with random matrices (main properties)
- Be familiar with some application of graphical models

## Transferable skills

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

address new problems with confidence.

# Study

## Study time

| Type | Required |
|------|----------|
| Lectures | 30 sessions of 1 hour (77%) |
| Seminars | 9 sessions of 1 hour (23%) |
| Total | 39 hours |

### Private study description

No private study requirements defined for this module.

## Costs

No further costs have been identified for this module.

# Assessment

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

### Assessment group D1

| | Weighting | Study time |
|---|---|---|
| Written homework | 15% | |
| Written homework (4 example sheets) | | |
| In-person Examination | 85% | |

- Answerbook Gold (24 page)

### Assessment group R

| | Weighting | Study time |
|---|---|---|
| In-person Examination - Resit | 100% | |

- Answerbook Gold (24 page)

**Feedback on assessment**

Marked homework and exam feedback.

[Past exam papers for MA3K0](#)

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# 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-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
- UCSA-G4G1 Undergraduate Discrete Mathematics
  - Year 3 of G4G1 Discrete Mathematics
  - Year 3 of G4G1 Discrete Mathematics
- Year 3 of UCSA-G4G3 Undergraduate Discrete Mathematics
- Year 4 of UCSA-G4G4 Undergraduate Discrete Mathematics (with Intercalated Year)
- Year 4 of UCSA-G4G2 Undergraduate Discrete Mathematics with Intercalated Year
- 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

This module is Core option list B for:

- UMAA-GV17 Undergraduate Mathematics and Philosophy
  - Year 3 of GV17 Mathematics and Philosophy
  - Year 3 of GV17 Mathematics and Philosophy
  - Year 3 of GV17 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:

- UMAA-GV18 Undergraduate Mathematics and Philosophy with Intercalated Year
  - Year 4 of GV18 Mathematics and Philosophy with Intercalated Year
  - Year 4 of GV18 Mathematics and Philosophy with Intercalated Year
- 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
- TMAA-G1PC Postgraduate Taught Mathematics (Diploma plus MSc)
  - Year 1 of G1PC Mathematics (Diploma plus MSc)
  - Year 2 of G1PC 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
- UMAA-G100 Undergraduate Mathematics (BSc)
  - Year 3 of G100 Mathematics
  - Year 3 of G100 Mathematics
  - Year 3 of G100 Mathematics
- UMAA-G103 Undergraduate Mathematics (MMath)
  - Year 3 of G100 Mathematics
  - Year 3 of G103 Mathematics (MMath)
  - Year 3 of G103 Mathematics (MMath)
  - Year 4 of G103 Mathematics (MMath)
  - Year 4 of G103 Mathematics (MMath)
- 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 4 of USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 5 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated 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 UMAA-G101 Undergraduate Mathematics with Intercalated 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
- Year 4 of USTA-Y603 Undergraduate Mathematics,Operational Research,Statistics,Economics (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-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
- Year 4 of USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
- Year 4 of USTA-GG17 Undergraduate Mathematics and Statistics (with Intercalated Year)

This module is Option list E for:

- USTA-G300 Undergraduate Master of Mathematics,Operational Research,Statistics and Economics
  - Year 3 of G30D Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
  - Year 4 of G30D Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)
- 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 5 of G30H Master of Maths, Op.Res, Stats & Economics (Statistics with Mathematics Stream)