MA241-10 Combinatorics

24/25

Department
Warwick Mathematics Institute
Level
Undergraduate Level 2
Module leader
Rob Silversmith
Credit value
10
Module duration
10 weeks
Assessment
Multiple
Study location
University of Warwick main campus, Coventry

Description

Introductory description

Combinatorics is the study of finite mathematical structures, and is one of the most widely applicable fields of mathematics. Enumerative combinatorics, i.e. the study of counting problems, is one of the oldest parts of mathematics, and a vast wealth of ideas and techniques aimed at combinatorial problem-solving have been developed — these ideas underpin arguments across all fields of mathematics and the sciences. Graph theory, the study of networks and connectivity, is an extremely broad and rich area, whose origin is often credited to Euler. Graph theory also has widespread applications in mathematics and the sciences, especially in computer science. The aim of this module is to introduce many of the basic concepts, ideas, and techniques in the theory, and most importantly, to give students the opportunity to use these techniques to solve combinatorial problems.

Module web page

Module aims

To introduce students to the basic problems and techniques in enumerative combinatorics and graph theory, and to develop their creative combinatorial problem-solving skills.

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.

I Enumerative combinatorics
-Basic counting (Lists with and without repetitions, Binomial coefficients and the Binomial Theorem)
-Applications of the Binomial Theorem (Multinomial Theorem, Multiset formula, Principle of inclusion/exclusion)
-Linear recurrence relations and the Fibonacci numbers
-Generating functions and the Catalan numbers
-Permutations, Partitions and the Stirling and Bell numbers

II Graph Theory
-Basic concepts (isomorphism, connectivity, Euler circuits)
-Trees (basic properties of trees, spanning trees, counting trees)
-Planarity (Euler's formula, Kuratowski's theorem, the Four Colour Problem)
-Matching Theory (Hall's Theorem and Systems of Distinct Representatives)
-Elements of Ramsey Theory
III Boolean Functions

Learning outcomes

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

- Combine covered techniques with their own creativity to solve combinatorial problems
- Work with the basic definitions and theorems of enumerative combinatorics, graph theory, and Ramsey theory
- Construct bijective proofs of numerical identities
- Adapt the ideas and skills of the module to understand new combinatorial structures
- Adapt the ideas of proofs of theorems in the module to new settings

Indicative reading list

Edward E. Bender and S. Gill Williamson, Foundations of Combinatorics with Applications, Dover Publications, 2006. Available online at the author's website:
http://www.math.ucsd.edu/~ebender/CombText/
John M. Harris, Jeffry L. Hirst and Michael J. Mossinghoff, Combinatorics and graph theory, Springer-Verlag, 2000.

Subject specific skills

Creative problem-solving in a broad range of mathematical contexts, learning to recognize when a given problem is equivalent to a previously-known one, learning to compute examples and spot recursions or other patterns that allow one to solve the general problem, comfort working with generating functions, ability to construct rigorous arguments in graph theory.

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 (30%)
Seminars	9 sessions of 1 hour (9%)
Private study	61 hours (61%)
Total	100 hours

Private study description

Review lectured material and work on set exercises.

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
Assignments	10%	
4 fortnightly assignments during the term.		
Examination	90%	

- Answerbook Pink (12 page)

Assessment group R1

	Weighting	Study time
In-person Examination - Resit	100%	

	Weighting	Study time

- Answerbook Pink (12 page)

Feedback on assessment

Marked assignments and exam feedback.

Past exam papers for MA241

Availability

Courses

This module is Core 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

This module is Optional for:

- Year 2 of UCSA-I1N1 Undergraduate Computer Science with Business Studies

This module is Core option list A for:

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

This module is Core option list B for:

- 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-GV19 Undergraduate Mathematics and Philosophy with Specialism in Logic and Foundations

This module is Option list A for:

- UMAA-G105 Undergraduate Master of Mathematics (with Intercalated Year)

    - Year 2 of G105 Mathematics (MMath) with Intercalated Year
    - Year 4 of G105 Mathematics (MMath) with Intercalated Year
- UMAA-G100 Undergraduate Mathematics (BSc)
    - Year 2 of G100 Mathematics
    - Year 2 of G100 Mathematics
    - Year 2 of G100 Mathematics
    - Year 3 of G100 Mathematics
    - Year 3 of G100 Mathematics
    - Year 3 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 3 of G100 Mathematics
    - Year 3 of G103 Mathematics (MMath)
    - Year 3 of G103 Mathematics (MMath)
- 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)
- USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
    - Year 2 of GG14 Mathematics and Statistics
    - Year 2 of GG14 Mathematics and Statistics
- UMAA-G101 Undergraduate Mathematics with Intercalated Year
    - Year 2 of G101 Mathematics with Intercalated Year
    - Year 4 of G101 Mathematics with Intercalated Year

This module is Option list B for:

- UCSA-G500 Undergraduate Computer Science
    - Year 2 of G500 Computer Science
    - Year 2 of G500 Computer Science
- UCSA-G503 Undergraduate Computer Science MEng
    - Year 2 of G500 Computer Science
    - Year 2 of G503 Computer Science MEng
    - Year 2 of G503 Computer Science MEng
- 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