

# MA252-12 Combinatorial Optimisation

**22/23**

**Department**

Warwick Mathematics Institute

**Level**

Undergraduate Level 2

**Module leader**

Oleg Pikhurko

**Credit value**

12

**Module duration**

10 weeks

**Assessment**

Multiple

**Study location**

University of Warwick main campus, Coventry

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## Description

### Introductory description

The focus of combinatorial optimisation is on finding the "optimal" object (i.e. an object that maximises or minimises a particular function) from a finite set of mathematical objects. Problems of this type arise frequently in real world settings and throughout pure and applied mathematics, operations research and theoretical computer science. Typically, it is impractical to apply an exhaustive search as the number of possible solutions grows rapidly with the "size" of the input to the problem. The aim of combinatorial optimisation is to find more clever methods (i.e. algorithms) for exploring the solution space.

[Module web page](#)

### Module aims

To introduce students to basic concepts and techniques of combinatorial optimisation.

### 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.

This module provides an introduction to combinatorial optimisation. Our main focus is on several

fundamental problems arising in graph theory and algorithms developed to solve them. These include problems related to shortest paths, minimum weight spanning trees, matchings, network flows, cliques, colourings and matroids. We will also discuss "intractable" (e.g. NP-hard) problems.

## Learning outcomes

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

- Upon completion of the module the students should be able to apply various combinatorial structures (graphs, matroids, etc.) and basic algorithmic techniques (breadth-first search, depth-first search, etc.) to describe and solve fundamental problems of combinatorial optimization (shortest path, travelling salesman, etc.).

## Indicative reading list

Main Reference:

B. Korte and J. Vygen, *Combinatorial Optimization: Theory and Algorithms*, Springer, 6th Edition, 2018. E-book available through the Warwick Library; click the link.

Other Resources:

A. Bondy and U. S. R. Murty, *Graph Theory with Applications*, Elsevier, 1976. Available through the link.

W.J. Cook, William H. Cunningham, W. R. Pulleybank, and A. Schrijver, *Combinatorial Optimization*, Wiley-Interscience Series in Discrete Mathematics, 1998.

C.H. Papadimitriou and K. Steiglitz, *Combinatorial Optimization: Algorithms and Complexity*, Dover Publications, 1998.

## Subject specific skills

The module will help the students to develop an algorithmic style of thinking.

## Transferable skills

Upon completion of the module the students should be able to formalise real-life optimisation problems and apply formal methods to solve them.

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## Study

### Study time

Type	Required
Lectures	30 sessions of 1 hour (25%)
Total	120 hours

<b>Type</b>	<b>Required</b>
Tutorials	9 sessions of 1 hour (8%)
Private study	81 hours (68%)
Total	120 hours

### **Private study description**

Review lectured material and work on set exercises.

### **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 B1**

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

#### **Assessment group R**

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

### **Feedback on assessment**

Exam feedback.

[Past exam papers for MA252](#)

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### **Availability**

### **Courses**

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 3 of UMAA-GL11 Undergraduate Mathematics and Economics
- USTA-G1G3 Undergraduate Mathematics and Statistics (BSc MMathStat)
  - Year 2 of G1G3 Mathematics and Statistics (BSc MMathStat)
  - Year 3 of G1G3 Mathematics and Statistics (BSc MMathStat)
  - Year 4 of G1G3 Mathematics and Statistics (BSc MMathStat)
- USTA-G1G4 Undergraduate Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
  - Year 4 of G1G4 Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
  - Year 5 of G1G4 Mathematics and Statistics (BSc MMathStat) (with Intercalated Year)
- USTA-GG14 Undergraduate Mathematics and Statistics (BSc)
  - Year 2 of GG14 Mathematics and Statistics
  - Year 2 of GG14 Mathematics and Statistics
- 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 Core option list B for:

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

This module is Core option list C for:

- Year 2 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:

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

- Year 2 of G105 Mathematics (MMath) with Intercalated Year
- Year 3 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)
- UMAA-G106 Undergraduate Mathematics (MMath) with Study in Europe
  - Year 2 of G106 Mathematics (MMath) with Study in Europe
  - Year 3 of G106 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)
- Year 3 of UPXA-FG33 Undergraduate Mathematics and Physics (BSc MMathPhys)
- UPXA-GF13 Undergraduate Mathematics and Physics (BSc)
  - Year 2 of GF13 Mathematics and Physics
  - Year 2 of GF13 Mathematics and Physics
  - Year 3 of GF13 Mathematics and Physics
  - Year 3 of GF13 Mathematics and Physics
- UPXA-FG31 Undergraduate Mathematics and Physics (MMathPhys)
  - Year 2 of FG31 Mathematics and Physics (MMathPhys)
  - Year 2 of FG31 Mathematics and Physics (MMathPhys)
- Year 4 of UPXA-GF14 Undergraduate Mathematics and Physics (with Intercalated Year)
- 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:

- Year 2 of USTA-G300 Undergraduate Master of Mathematics, Operational Research, Statistics and Economics
- 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 Intercalated Year)

- 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
  - 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 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)