

## Engineering Tripos Part IIB, 4M26: Algorithms and Data Structures, 2021-22

### Module Leader

[Dr I Budvytis](#) [1]

### Lecturer

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### Timing and Structure

Lent term. 16 lectures (including 3 examples classes). Intake: Part IIB students, Part IIA (optional).

### Prerequisites

Due to a novel form of assessment (coding based exam) the intake of this course will be limited to 30-60 students for the first year (2021-2022). Only students who have strong skills in coding with Python are expected to attend this module. Students who are interested in taking this module will be required to pass a coding test in Michaelmas 2021. It is important to have an alternative course in mind for Lent term in case one does not pass the test.

### Aims

The aims of the course are to:

- Introduce the principles behind algorithm and data structure design and evaluation.
- Cover key topics including elementary and advanced data structures, sorting algorithms, graph algorithms, etc.
- Provide an extensive hands-on understanding of the aforementioned topics via coding-focused computerised examples papers and exam.

### Objectives

As specific objectives, by the end of the course students should be able to:

- Analyse computational efficiency of most algorithms.
- Re-implement and debug algorithms taught under time constraints.
- Correctly choose the right algorithmic solution and data structures for the problem encountered.
- Understand relative theoretical and practical advantages and disadvantages of various methods.
- Devise and implement new algorithms or modify existing algorithms to solve previously unencountered tasks.

### Content

- **Introduction (1L)**
  - Algorithms and Data Structures: what is it, why study it and how? Introduction of the coding platform and other resources. Applications.
- **Fundamentals of Algorithms (2L)**
  - Elementary data structures - stacks and queues, linked-lists, arrays, dictionaries. Algorithmic

complexity and NP completeness. Strategies for algorithmic design: divide and conquer, dynamic algorithms, greedy algorithms.

- **Advanced Data Structures (2L)**
  - Hash tables, binary search trees, red-black trees, etc.
- **Sorting Algorithms (2L)**
  - Sorting algorithms - Bubblesort, Heapsort, Quicksort, etc. Sorting in linear time.
- **Graph Algorithms (3L)**
  - Graph algorithms - shortest path (BFS, DFS, Dijkstra, Bellman-Ford, etc), maximum flow (Ford-Fulkerson), minimum spanning trees (Kruskal's, Primm's).
- **Computational Geometry and Mathematical Algorithms (2L)**
  - Line segment intersection, closest pair, convex hull. DFT and FFT, Matrix multiplication and inversion, number theoretic algorithms.
- **Advanced Topics (1L)**
  - Multi-threaded algorithms, approximation algorithms, differentiable programming.
- **Example classes (3L)**
  - Discussion of examples papers and past examination papers.

### Examples papers

A computerised exam is held at the Design Project Office (DPO). A mixture of (i) coding, (ii) simple pen-and-paper algorithm run-through and (iii) short theoretical questions are provided in the exam paper. See example question here: [http://mi.eng.cam.ac.uk/~ib255/files/4M26-Algorithms\\_and\\_Data\\_Structures...](http://mi.eng.cam.ac.uk/~ib255/files/4M26-Algorithms_and_Data_Structures...) [2]

### Booklists

**Introduction to Algorithms** (3rd ed) by *Cormen, T., Leiserson, C., Rivest, R., Stein, C.* The MIT Press.  
ISBN:978-0-262-03384-8.

Also, please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

### Examination Guidelines

Please refer to [Form & conduct of the examinations](#) [3].

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### Links

[1] <mailto:ib255@cam.ac.uk>

[2] [http://mi.eng.cam.ac.uk/~ib255/files/4M26-Algorithms\\_and\\_Data\\_Structures-S1-Jupyter-Notebook.pdf](http://mi.eng.cam.ac.uk/~ib255/files/4M26-Algorithms_and_Data_Structures-S1-Jupyter-Notebook.pdf)

[3] <https://teaching25-26.eng.cam.ac.uk/content/form-conduct-examinations>