

Engineering Tripos Part IIB, 4M26: Algorithms and Data Structures, 2022-23

Module Leader

[Dr I Budvytis](#) [1]

Lecturers

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Timing and Structure

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

Prerequisites

Due to a novel form of assessment (coding based exam) the intake of this course will be limited to approximately 30 Part IIB students for the first year (2022-2023). 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 2022. It is important to have an alternative course in mind for Michaelmas/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 are algorithms, why study algorithms 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. Strategies for algorithmic design: divide and conquer, dynamic algorithms, greedy algorithms.
- **Advanced Data Structures (2L)**
 - Hash tables, binary search trees, red-black trees, b-trees.
- **Sorting Algorithms (2L)**
 - Sorting algorithms - Heapsort, Quicksort, sorting in linear time.
- **Graph Algorithms (3L)**
 - Graph algorithms - shortest path (BFS, DFS, Dijkstra, Bellman-Ford), topological sorting, strongly connected components, maximum flow (Ford-Fulkerson), minimum spanning trees (Kruskal's, Prim's).
- **Further Topics (2L)**
 - Parallel algorithms, matrix operations, NP-completeness, approximation algorithms.
- **Recent Developments (1L)**
 - Large language models for code generation.
- **Example classes (3L)**
 - Discussion of examples papers and past examination papers.

Further notes

The information regarding **coding test in Michaelmas 2022** will be made available via Moodle page of [4M26 - Algorithms and Data Structures](#) [3].

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... [4]

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](#) [5].

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Links

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

[2] <mailto:ib255@cam.ac.uk>, sma71@cam.ac.uk

[3] <https://www.vle.cam.ac.uk/course/view.php?id=228062>

[4] http://mi.eng.cam.ac.uk/~ib255/files/4M26-Algorithms_and_Data_Structures-S1-Jupyter-Notebook.pdf

[5] <https://teaching24-25.eng.cam.ac.uk/content/form-conduct-examinations>