

## Engineering Tripos Part IIB, 4F14: Computer Systems, 2024-25

### Module Leader

[Prof Andrew Gee](#) [1]

### Lecturers

[Prof Andrew Gee and Prof Per Ola Kristensson](#) [2]

### Timing and Structure

Lent Term. 12 lectures and 2 examples classes. 75% exam / 25% coursework. Lectures will be recorded.

### Prerequisites

Part 1 Digital Circuits and Computing, including an understanding of C++ as taught in the Mars Lander project and the Part 1B Device Programming exercise. Students will be expected to write small programs in C++.

### Aims

The aims of the course are to:

- Describe the computer hardware that underlies modern information processing systems.
- Explain how to write multithreaded software that runs on such hardware.

### Objectives

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

- Appreciate the basic components needed to construct a computer and the different ways to interconnect these components, including the various ways of exploiting parallelism.
- Compare the instruction sets, implementation issues and performance of CISC and RISC architectures.
- Design efficient hardware for computer arithmetic.
- Understand the operation of pipelined datapaths.
- Describe memory organisation, addressing schemes and the use of caches; and their effects on performance.
- Compare the various ways of handling input and output in a computer system.
- Understand the concept of a memory model.
- Understand basic concurrency concepts.
- Design and implement thread-safe algorithms in C++.

### Content

#### Computer Systems (8 lectures and 2 examples classes, Prof Andrew Gee)

- Computer architecture, historical perspectives.
- Instruction set architectures, RISC vs CISC.
- ALU design, datapaths and control, pipelining.
- Memory hierarchy, caches, virtual memory.

- Input/output, bus organization, polling and interrupt-driven I/O, DMA.
- Parallel processing, SIMD and MIMD architectures.

**Assessment:** examination (75%), candidates to attempt two questions from a choice of three

## Parallel Programming (4 lectures, Prof Per Ola Kristensson)

- C++ memory model.
- Race conditions, mutual exclusion, synchronization, starvation.
- Thread-safe data structures.
- C++ threading library.

**Assessment:** coursework (25%)

## Coursework

Multithreaded programming using the C++ memory model and threading libraries. The programming exercise is an opportunity to experience how theoretical concepts from the lectures translate into actual working code using a state-of-the-art industry standard threading library. Time required: 4-8 hours programming plus 15 minutes demonstrating and discussing your code with an assessor. Please note that coursework assessment is not anonymous.

| Coursework                                                                                                                                                                                                                                                                                                                                 | Format                                                                      | Due date<br>& marks                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------|
| <b>Multithreaded programming</b><br><br><u>Learning objectives:</u> <ul style="list-style-type: none"><li>• To gain practical experience with the C++ threading library.</li><li>• To design and implement thread-safe data structures.</li><li>• To practice concurrency control so as to avoid race conditions and starvation.</li></ul> | Individual<br><br>Demonstrating your software<br><br>Not anonymously marked | Software to be<br>Lent Term<br><br>Assessment<br>Term [15/60] |

## Booklists

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

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