



SYSC Computer Systems Architecture

4310

Calendar description

Evolution of computer systems architecture to improve performance. Memory hierarchy, hardware accelerators. Instruction level parallelism, pipelining, vector processing, superscalar, out-of-order execution, speculative execution. Thread level parallelism, multi-core, many-core, heterogeneous systems. Processor-level interconnect bus, non-uniform memory access. Application-oriented architectures. Virtualization.

Lectures three hours a week, laboratory three hours alternate weeks.

<http://calendar.carleton.ca/undergrad/courses/SYSC/>

Prerequisites

SYSC 3320, and enrolment in Computer Systems Engineering.

Precludes additional credit for SYSC 4507.

Prior knowledge

Students should have:

- Knowledge and experience in the C programming language.
- Basic knowledge of computer architecture.
- Knowledge of hardware Description Languages (Verilog HDL).

Course objectives

- Understand advanced computer architecture and performance-driven microarchitectural features.
- Recognize the requirements placed on the memory hierarchy by modern computer architectures.
- Understand the need for and challenges associated with the growing heterogeneity in computer architecture solutions.

In order to meet these objectives, lectures throughout this course will describe the concepts of computer architecture, showing the evolution towards modern multi-core processors. Laboratory work will provide meaningful practical assignments that exercise these concepts.

List of topics

- Memory hierarchy and Virtual memory
- OS hardware support and pipelined processors
- Superscalar processors
- Out of order execution
- Multithreaded processors
- Multicore processors
- Heterogeneous multicore
- Accelerators and High Level Synthesis
- NUMA for parallel computing

Learning outcomes

By the end of this course, students should have:

- Proficiency ILP and TLP concepts.
- A comprehensive understanding of different processor micro-architectures.
- Ability to design subsets of modern processor systems.
- Experience in modeling performance of computer systems.

Graduate Attributes (GAs)

The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes at the time of graduation. Activities related to the learning outcomes listed above are measured throughout the course and are part of the department's continual improvement process. Graduate attribute measurements will not be taken into consideration in determining a student's grade in the course. For more information, please visit: <https://engineerscanada.ca/>.

Graduate Attribute	Learning outcome(s)
3.1: Investigation: Developed: Complex problem assessment	
3.2: Investigation: Developed: Design of experiment	
3.3: Investigation: Developed: Experimental procedure	
3.4: Investigation: Developed: Data reduction methods and results	
5.3: Use of Engineering Tools: Developed: Tools for design, experimentation simulation, visualization, and analysis	
5.5: Use of Engineering Tools: Introduced: Limitations of such tools and the assumptions inherent in their use	

Accreditation Units (AUs)

For more information about Accreditation Units, please visit: <https://engineerscanada.ca/>.

The course has a total of 46 AUs, divided into:

- Engineering Science: 50%
- Engineering Design: 50%

Instructor and TA contact

Instructor: Paulo Garcia (paulo.garcia@carleton.ca)

Textbook (or other resources)

Computer Architecture: A Quantitative Approach Paperback – Illustrated, Dec 7 2017 by John L. Hennessy (Author), David A. Patterson

Evaluation and grading scheme

This course will have 3 assessment components: 1 midterm exam, laboratory assignments, and 1 final exam. The default calculation of your final grade will be:

40% midterm + 10% labs + 50% final exam.

If your final exam grade is higher than the midterm grade, then the grade will be calculated as follows:

10% labs + 90% final exam.

Midterm exam will be performed through a quiz on Brightspace, which will be open for a certain time period (tentatively, 16 hours) during lecture day. Deferred midterms, due to the circumstances described below in the “General regulations” section, will be offered a week after the original midterm exam.

You will receive full marks for the lab section, as long as you submit all the labs, regardless of the quality of code. Failing to submit lab assignments will result in the grade being downgraded accordingly. Submitting plagiarized work will result in a mark of 0 for the entire course (final grade of F).

Final exam will follow University and Departmental procedures for regularly scheduled final exams.

During exams, you may consult all course slides available on cuLearn, as well as the provided code examples (e.g., lab solutions). No other materials may be consulted. You may not communicate with each other or anyone else during an exam. Plagiarized work or any other academic violation will result in a mark of 0 for the entire course (final grade of F).

Breakdown of course requirements

Laboratory assignments require a suitable HDL (Verilog) synthesizer/compiler. Please download and install one of the 3 recommended software: (1) Verilator (recommended); (2) Icarus Verilog; or (3) Vivado Design Suite (there is a free license (webpack) that you can use).

Tentative week-by-week breakdown

This course will be offered in a hybrid format (asynchronous self-learning combined with synchronous sessions). Recommended dates for completion of each topic are displayed on the Brightspace page.

Important Information

We will hold virtual classes over Zoom once a week. The corresponding link is on Brightspace.

At each virtual class, you are expected to have read all the materials available on Brightspace corresponding to the topics up to that class (the instructor will make periodic announcements about which materials you are expected to have read by what time). Virtual classes will not be Zoom versions of a face-to-face lecture: the instructor will provide a brief overview or a demonstration of concepts, and the remainder of the time will be used for discussions and questions, similar to office hours. Please come to each virtual class prepared, having studied the materials and attempted the lab exercises to make the most of them.

Zoom operation: please keep your microphones muted at all times. When you wish to ask a question or make a comment, just type “question” in the chat. A TA will keep a list of who wants to speak, in what order, and then call upon you. At that time, un-mute your microphone.

We will make every effort to record Zoom lectures and make them available to you, so you can revise discussions later or observe the lecture if you were not able to participate.

General regulations

Attendance: Students are expected to attend all lectures and lab periods. The University requires students to have a conflict-free timetable. For more information, see the current *Undergraduate Calendar, Academic Regulations of the University, Section 2.1.3, Course Selection and Registration and Section 2.1.7, Dereistration*.

Health and Safety: Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: <http://sce.carleton.ca/courses/health-and-safety.pdf>

Deferred Term Work : Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. For more information, see the current *Undergraduate Calendar, Academic Regulations of the University, Section 4.4, Deferred Term Work*.

Appeal of Grades : The processes for dealing with questions or concerns regarding grades assigned during the term and final grades is described in the *Undergraduate Calendar, Academic Regulations of the University, Section 3.3.4, Informal Appeal of*

Grade and Section 3.3.5 Formal Appeal of Grade.

Academic Integrity: Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: <https://carleton.ca/registrar/academic-integrity/>. This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

Plagiarism: Plagiarism (copying and handing in for credit someone else's work) is a serious instructional offense that will not be tolerated.

Academic Accommodation: You may need special arrangements to meet your academic obligations during the term. You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at <http://www.carleton.ca/equity/>. For an accommodation request, the processes are as follows:

- **Pregnancy or Religious obligation:** Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see <https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf>
- **Academic Accommodations for Students with Disabilities:** The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your **Letter of Accommodation** at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (*if applicable*). **Requests made within two weeks will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (*if applicable*).
- **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: <https://carleton.ca/sexual-violence-support/>.
- **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that

result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

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