# Carleton University

Dept. of Systems and Computer Engineering Introduction to Computer Organization and Architecture—SYSC 2320

Winter 2019

### Course Outline

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#### **Teaching Assistants**

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**Course Description** This is a first course on the organization of computer systems at the hardware/software interface. Understanding this interface involves the processor's Instruction Set Architecture (ISA), the system's memory organization, and the system's I/O peripherals. Engineers working with microcontrollers (including mobile devices) must understand computer systems at this level, and these concepts form the foundation on which more powerful computer systems are based (such as desktop systems, servers, multi-processors, and supercomputers).

The processor's native assembly language is a central software topic in the course. The increasing use of high level languages such as C is reducing the need for assembly language programming proficiency. As a result, the course will focus more on understanding how an assembly language manipulates information at the hardware/software interface and can support a high level language, and will not emphasize developing complete applications in assembly language.

**Calendar Description** Computer organization: processor, memory, input/output, system bus. Number systems: binary, decimal, hexadecimal. Assembly language programming: representation of data, instruction encoding, execution. Devices: keyboard, programmable timer, parallel interface. Input/output methods: polling, hardware/software interrupts.

**Prerequisites** SYSC 2006 and SYSC 2310. This course precludes additional credit for SYSC 2001 and SYSC 3006.

Students who have not satisfied the prerequisites for this course must either a) withdraw from the course, or b) obtain a prerequisite waiver online at http://www.carleton.ca/engineering-design/current-students/undergrad-academic-support/, or c) will be deregistered from the course after the last day to register for courses.

Learning Objectives This course will teach the student to:

- 1. develop hardware circuits at the core of microprocessors and microcontrollers,
- 2. develop hardware alternate designs to achieve similar objectives,
- 3. design finite state machines necessary for the implementation of various instructions,
- 4. develop machine code and corresponding assembly language programs to implement specific programming tasks;
- 5. use FPGA modules to build hardware circuits using the Verilog hardware description language, and to
- 6. build hardware circuits necessary to interface input/output modules using polling and interrupt-based techniques.

**Graduate Attributes** Graduate Attributes measured in this course are: 1.5.S - Knowledge base: Disciplinespecific concept SCE-2: Computer Systems; 4.5 - Design: Design implementation/task(s) definition; and 4.6 - Design: Alternate solution(s) definition. The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes. Activities related to the learning outcomes listed here are intended to develop students competence in: GA 1.5.S (a knowledge base in computer systems engineering), GA 4.5 (design implementation and definition in computer systems), and GA 4.6 (considering of alternate solutions). Data obtained from exam questions related to learning outcomes 16 will be collected to assess students progress towards possessing GA 1.5.S, GA 4.5 and GA 4.6. In particular, learning outcomes (16) will be used to evaluate GA 1.5.S, learning outcomes 46 will be used to evaluate GA 4.5 and GA 4.6. The latter are intended to prepare students to undertake learning activities that develop competence in designing solutions for complex, open-ended engineering problems in subsequent courses.

Website The course will use the SYSC2320A (LEC) Winter 2018 website on cuLearn. Course materials will be placed on the website for student personal use, and students are responsible for checking the website frequently. Student, TA or professor materials created for this course (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s).

**Textbooks** A specific textbook is not recommended in the course. Course notes and supporting material will be supplied via the course webpage for student personal use.

**Attendance** Students are expected to attend all lectures and labs. The Faculty of Engineering and Design requires its students to have a conflict-free timetable, so requests to accommodate missed exams, assignment due dates, etc., because of conflicts with other courses, jobs or vacation plans will not be considered.

**Laboratory** There will be 10 graded laboratories that will be posted on the course website. The first session of Lab 1 is on Monday, Jan. 14. Lab attendance is mandatory, with work to be demonstrated by the end of the lab period. Marks will only be awarded for labs demonstrated during the students schedule lab time (according to section registration). During the scheduled lab times, TA assistance will be available. The computer lab is open seven days a week, whenever the building is open. You may use the lab at any time other than those timeslots when the lab is reserved for other courses or for other sections of this course.

**Study Questions** Study questions will be posted on the course website, but will not be collected and graded.

Students are encouraged to discuss issues when working on labs; however, they are expected to do their own lab work individually. Suspected plagiarism will be investigated and may result in a mark of zero for the lab. As well, alleged instructional offences will be reported to the Associate Dean of Engineering. (Please see the current undergraduate calendar, "Instructional Offences", in the Undergraduate Calendar Supplement).

Students are warned that the labs and study questions form a very important part of this course doing these (by yourself) is an excellent way for you to learn the material. In this context, it should be noted that copying labs is, even if you are not caught, a self-defeating exercise. Historically, most of the students who resorted to copying did not do particularly well on the mid-term or final exam.

**Quizzes** Students will be expected to participate in in-class discussions and to write 5-minute quizzes. Quiz times will be announced beforehand as the course progresses.

Midterm Exam There will be one closed book, no-calculator, midterm exam. The midterm exam will be held at 4:00 PM on Friday, February 15, 2019 in room TBD.

**Final Exam** A closed book, no-calculator, final exam will be held during the University's formal examination period.

Students who miss the final exam may be granted permission to write a deferred examination (see the Undergraduate Calendar for regulations on deferred exams).

#### Grading Scheme

- Labs: 20%
- Quizzes: 10%
- Midterm Exam (Grade cannot be shifted to Final): 25%
- Final exam: 45%

Medical Certificates A medical certificate must adhere to the format required by the Registrar. The format is available as a PDF form through the Registrar's website http://www.carleton.ca/registrar/forms. All medical certificates must be presented immediately upon return from the illness; they will not be accepted after the fact.

Academic accommodation for religious obligations Students who require accommodations due to religious obligations must follow the procedures described in Section 2.10 of the "Academic Regulations of the University".

**Students with Disabilities** Students with disabilities requiring academic accommodations in this course should contact the Paul Menton Centre for Students with Disabilities (PMC) (UC 500) to complete the necessary forms. After registering with the PMC, make an appointment with your instructor to discuss your specific needs at least two weeks prior to the mid-term exam. This will allow sufficient time to make the required arrangements.

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).

**Lecture Content** The following themes are interwoven in the lectures throughout the course.

- Computer system architecture (basics)
  - Computer system components: processor, memory, I/O, interconnection bus
  - Information encoding, data representation in binary, hexadecimal
  - Number systems, unsigned integers, signed integers, 2's complement
  - Computer hardware organization: datapath and control
  - Registers, instruction cycle
- Hardware/software interface (Instruction Set Architecture)
  - Instructions: data manipulation, data transfer, control flow, instruction encoding
  - Computer arithmetic, flags
- Microcontroller example
  - Microcontroller concept
  - System on Chip, memory model, ISA
- Assembly language programming
  - Code snippets, examples
  - Assembly process, linker, loader
- High-level Language Support
  - Variables, arrays, structures, assignment, looping, conditional statements
  - Procedures and functions, parameter passing
- Peripheral I/O and Interrupts
  - Register model of peripheral devices: parallel I/O, serial I/O, timers
  - Polling
  - Hardware interrupts: vectored and prioritized, Nested Vector Interrupt Controller(NVIC)
  - Examples: timer, serial
  - Software interrupts, o/s calls

## **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 1.2, Course Selection and Registration and Section 1.5, Deregistration.

**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 4

**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 2.6, 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 2.7, Informal Appeal of Grade and Section 2.8, 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 Universitys Senate.

**Plagiarism:** Plagiarism (copying and handing in for credit someone elses 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 obligation:** write to me 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 seehttps://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf.

**Religious obligation:** write to me 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 orpmc@carleton.cafor 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). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult https://carleton.ca/pmc/students/dates-and-deadlines/ 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 Carletons Sexual Violence Policy. For 5 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/Accommodationfor-Student-Activities-1.pdf

**Copyright on Course Materials:** The materials created for this course (including the course outline and any slides, posted notes, labs, project, assignments, quizzes, exams and solutions) are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).