Instructor: Mohamed Atia, mohamed.atia@carleton.ca, room MC7030. Office hours are flexible pre-arranged by individual emails with the instructor.

TA: Ali Farsiabi, alifarsiabi@cmail.carleton.ca, contacts and office hours to be decided

Course Number: SYSC 3320, Calendar Description:

System on Chip (SoC)-based computer system design. SoC internal organization. Cache memory. Interfacing: external memory, hardware subsystems. Direct memory access. Floating point units. Introduction to field programmable gate arrays.

Prerequisites: SYSC 3310 and third-year status in Computer Systems Engineering, or permission of the Department

Course Objectives

The course aims at developing solid understanding of modern computing systems design approaches and demonstrating how programmable logic and processor systems are mixed together on a single chip to design optimized computer systems. The course also aims at equipping students with the necessary hands-on experience to design and implement SoC-based computer systems.

Learning Outcomes and Graduate Attributes

We are in post-PC computer systems era. Computer systems are no longer simple separate components connected together. Emerging applications such as Internet-of-things (IoT), wearable technology, automated driving, intelligent machines require optimized high-performance, low-power, low-cost computer systems. This course will teach modern computing systems design showing how complete digital systems can be built and implemented on a chip (SoC) where engineers have flexibility to design each single component of systems to maximize performance and optimize costs. The Canadian Engineering Accreditation Board requires graduates of engineering programs to possess 12 attributes. Activities related to the learning outcomes are intended to develop students' competence in the GA's listed below

<table>
<thead>
<tr>
<th>Outcome</th>
<th>GA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing solid understanding of digital systems design approaches</td>
<td>1.5.S</td>
</tr>
<tr>
<td>Gaining hands-on experience in digital systems design/implementation.</td>
<td>3,4, and 5.1</td>
</tr>
<tr>
<td>Learning CAD tools for Hardware Design and Implementation.</td>
<td>3,4, and 5.1</td>
</tr>
<tr>
<td>Learning ARM architecture and ARM Assembly.</td>
<td>1.5.S</td>
</tr>
<tr>
<td>Using high-level design and implementation using C programming language.</td>
<td>4,5.1</td>
</tr>
<tr>
<td>Designing embedded computer systems using programmable logic (PL) and processors systems (PS).</td>
<td>4,5.1</td>
</tr>
</tbody>
</table>

Textbooks (or other resources)

The course material is based on multiple sources. Lecture notes and in-class work is the main source of information. For further knowledge, the following references are recommended but not mandatory:


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Evaluation and Grading Scheme

<table>
<thead>
<tr>
<th>Deliverable Type</th>
<th>Allocated Percentage</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratories</td>
<td>25%</td>
<td>5 Lab reports in total</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>20%</td>
<td>Closed book</td>
</tr>
<tr>
<td>Popup Quizzes</td>
<td>5%</td>
<td>In class quizzes at random dates</td>
</tr>
<tr>
<td>Final Exam</td>
<td>50%</td>
<td>Closed book</td>
</tr>
</tbody>
</table>

- Please consult the course website frequently on the CuLearn for important course updates
- Laboratory rules/regulations will be posted on the course CuLearn site.
- Appointments can be set up through email if extra consultation hours are needed.
- Five (5) laboratories are to be completed. You must work in a group of two for all labs.
- A lab report is required by each group for each laboratory.
  - A report format and structure will be posted to CuLearn. All reports must follow this format/structure.
  - The report must be prepared according to the directions in the laboratory manual.
  - The report must be submitted electronically through CuLearn.
- The midterm and Final exams will be closed book.
- The instructor may provide bonus marks for special performance in-class participation
- The final examination is for evaluation purposes only and will not be returned to students. You will be able to make arrangements with the instructor or with the department office to see your marked final examination after the final grades have been made available

Week-by-Week breakdown

1- Digital Systems - Introduction
2- Computer System Architecture - Introduction
3- Digital Systems Design Approaches
4- Programmable Logic, FPGA (Field Programmable Gate Arrays)
5- VHDL (VHSIC Hardware Description Language)
6- Hybrid SoC Design Approach
7- ARM Internal Architecture
8- ARM Assembly
9- Pipelining and Superscalar Design
10-Input-Output and Interfacing (Interconnect, Interrupts, and Direct Memory Access)
11-Memory Organization-Technologies, Main Memory Addressing, and Cache Memory Access
12-Arithmetic Operations (Fixed-point and Floating-Point Arithmetic)
13-Digital Signal Processors (DSPs)

Lab Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Place</th>
<th>Group</th>
<th>Lab Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 24th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1O</td>
<td>Introduction to Vivado SoC HW/SW Design Tools and simple FPGA programmable logic design Experiment</td>
</tr>
<tr>
<td>Jan. 29th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1E</td>
<td>SoC-Design Experiment 1 (Hybrid Processor/Programmable Logic SoC)</td>
</tr>
<tr>
<td>Feb. 7th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1O</td>
<td>FPGA (Programmable Logic implementation of some computer sub-systems components)</td>
</tr>
<tr>
<td>Feb. 12th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1E</td>
<td>SoC-Design Experiment 2 (SoC with Interrupts)</td>
</tr>
<tr>
<td>Feb. 28th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1O</td>
<td>DPS (Fixed-point and Floating-Point Arithmetic)</td>
</tr>
<tr>
<td>Mar. 5th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1E</td>
<td></td>
</tr>
<tr>
<td>Mar. 14th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1O</td>
<td></td>
</tr>
<tr>
<td>Mar. 19th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1E</td>
<td></td>
</tr>
<tr>
<td>Mar. 28th 2019</td>
<td>11:35 am-2:25 pm</td>
<td>ME 3333B</td>
<td>L1O</td>
<td></td>
</tr>
</tbody>
</table>

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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

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 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 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
- 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 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). 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 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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