Carleton University
Department of Systems and Computer Engineering
SYSC 3320: Computer System Design - Winter 2020
Course Outline

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

TA: To be determined or Posted on CuLearn.

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.

Assumed Knowledge
Basic understanding of computer system organization, binary numbers systems, and digital logic.

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 hybrid SoC-based computer systems.

Learning Outcomes and Graduate Attributes

Upon completion of this course, students should know and understand:
1. Computer system design levels such as logic-gate, register-transfer-logic, assembly and high-level programming.
2. Modern SoC-based computer systems compared to conventional Modules-on-Board (MoB) systems.
3. ARM architectures and ARM Assembly.
4. Applications of SoC computer systems in new emerging applications such as Internet-of-things and wearables.
5. Major factors that controls computer systems design such as high-performance, low-power, and low-cost.
6. Flexibility to design single components of computer systems differently to balance performance versus costs.

Upon completion of this course, students should be able to:
7. Develop simple sub-systems of a computer using programmable logic (PL)
8. Implement PL-design using hardware description languages such as VHDL.
9. Use CAD tools (e.g. Vivado) for System-on-Chip (SoC) Design and Implementation.
10. Develop simple assembly programs for ARM architecture.
11. Use C programming language for SoC high-level design and implementation.
12. Design an embedded computer system using mixed programmable logic (PL) and processors systems (PS).

Graduate Attributes (GA’s)
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/.

<table>
<thead>
<tr>
<th>Graduate Attribute</th>
<th>Learning Outcome (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Base – 1.5.S Computer Systems</td>
<td>1-6</td>
</tr>
<tr>
<td>Investigation – 3.1 Complex Problem Assessment</td>
<td>7,12</td>
</tr>
<tr>
<td>Design – 4. 1 Clear Design Goals</td>
<td>7-12</td>
</tr>
<tr>
<td>Design – 4. 2 Detailed Design Specifications</td>
<td>7-12</td>
</tr>
<tr>
<td>Design – 4. 6 Alternative Solutions</td>
<td>7-12</td>
</tr>
<tr>
<td>Design – 4. 7 Evaluation based on Engineering Principles</td>
<td>7-12</td>
</tr>
</tbody>
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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:


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>3 Hours bi-weekly (Introductory Lab + 5 Lab projects)</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>20%</td>
<td>Closed book (cannot transferred to final exam)</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>
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- 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 at least two for all labs.
- At the end of each lab, each group must demonstrate their work to TAs.
- TAs will check students work and ask students few questions.
- 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.
Tentative 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 Projects Schedule (check central and CuLearn for exact lab times and locations)

<table>
<thead>
<tr>
<th>Week</th>
<th>Lab Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Vivado SoC HW/SW Design Tools.</td>
</tr>
<tr>
<td>2</td>
<td>Simple FPGA programmable logic Design Experiment</td>
</tr>
<tr>
<td>3</td>
<td>FPGA implementation of some computer sub-systems components</td>
</tr>
<tr>
<td>4</td>
<td>SoC-Design Experiment 1 - (Hybrid Processor/Programmable Logic SoC)</td>
</tr>
<tr>
<td>5</td>
<td>SoC-Design Experiment 2 (SoC with Interrupts)</td>
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<tr>
<td>6</td>
<td>DPS (Fixed-point and Floating-Point Arithmetic)</td>
</tr>
</tbody>
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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 2.1.3, Course Selection and Registration* and *Section 2.1.7, 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](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/](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.

@ Mohamed Atia, PhD, PEng
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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