Carleton UNIVERSITY | Department of Systems and Computer Engineering

SYSC 2310
Introduction to Digital Systems

Calendar description

Number systems: binary, decimal, hexadecimal. Digital representation of information. Computer arithmetic: integer, floating point, fixed point. Boolean logic, realization as basic digital circuits. Applications: simple memory circuits, synchronous sequential circuits for computer systems. Finite state machines, state graphs, counters, adders. Asynchronous sequential circuits. Races.

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

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

Prerequisites

(ECOR 1051 and ECOR 1052 and ECOR 1053 and ECOR 1054) or ECOR 1606 or SYSC 1005, and enrolment in Computer Systems Engineering, Communications Engineering, or Software engineering, and second-year status in Engineering.

Precludes additional credit for ELEC 2607.

Prior knowledge

Students should:

- Have a basic understanding of the ordinary mathematical system and algebra.

Course objectives

The objective of this course is to provide knowledge on fundamentals of digital systems. In the design and implementation of digital systems, all information is encoded, processed and communicated as binary values (i.e. using 0's and 1's). These systems are built from simple digital logic gates that manipulate binary values. Digital memory circuits are used to store binary values over time. Digital systems frequently utilize finite state machines to control the manipulation of information as a sequence of steps. A clock is often used to control the pace of data processing and communication. Although a clock provides a well-defined reference for sequencing steps, circuits can sometimes be designed to operate asynchronously (i.e., without a clock) to speed up processing.

List of topics

- Information representation
- Digital systems and binary numbers

- Basic logic gates
- Boolean algebra
- Gate-level minimization
- Combinational logic
- Combinational logic (cont.)
- Sequential circuits: Latches and flip-flops
- Synchronous sequential circuits: Counters, Registers, Memory
- Synchronous sequential circuits: Finite state machines. Multiplication and division
- Asynchronous circuits

Learning outcomes

By the end of this course, students should be able to:

- Define concepts of digital representation of information.
- Ability to work effectively with a variety of number systems and numeric representations, including signed and unsigned binary, hexadecimal, two's complement, fixed point, and floating point.
- Understand the basic building blocks of digital systems.
- Understand Boolean Algebra and formulate, analyze and simplify Boolean functions.
- Apply analysis skills to correctly describe the behavior of given combinational and sequential digital logic circuits.
- Able to design, implement and analyze combinational logic with digital gates and sequential circuits with flip-flops.
- Capable of designing and implementing simple finite state machines.

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)
1.7.S: Knowledge Base: Introduced: Electronics and circuits	1-7
2.1: Problem Analysis: Developed: Problem definition	2-7
4.6: Design: Introduced: Alternate solution(s) definition	4-7
4.7: Design: Developed: Evaluation based on engineering principles	4-7
5.1: Use of Engineering Tools: Introduced: Diagrams and engineering sketches	5-7

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:

Mostafa Taha

Email: mtaha@sce.carleton.ca

Online Zoom Hours: Mondays 10:00 AM to 11:00 AM.

Office: ME4436

TA Information:

(TBD)

Textbook (or other resources)

- "Digital Design: With an Introduction to the Verilog HDL, VHDL, and SystemVerilog, 6th Edition Mano & Ciletti ©2018 | Pearson | ISBN-13: 9780134549897"
- Links to Software, libraries, additional resources: For practicing basic digital design with common logic gates and verifying the design via simulation, a simple simulator is used. Logisim is a free software. It is a Java-based visual simulator for simple digital circuits. Instructions for download as well as a brief description of its use will be provided as part of the course material in cuLearn.
- All course material and instructional materials are covered by the rules stipulated in Copyright on Course Materials of General Regulations section below.

Evaluation and grading scheme

The course work will be evaluated as follows:

Component	Percentage
Labs	25%
Quizzes	20%
Midterm	25%
Final Exam	30%

Breakdown of course requirements

Lectures:

Lectures will be pre-recorded and be available to the students, along with any relevant materials, at the scheduled lecture time. Lectures will be recorded close to the actual scheduled time to address any feedback and to answer common questions. The recording of each lecture will be around 60 mins using one or two videos. The last 20

mins of each lecture will be dedicated to open discussions using a Zoom session. This will the time to answer any question related to the lecture, the homework, the quizzes, meet each other, and discuss any feedback. In order to better manage Zoom sessions and to save bandwidth, you are strongly recommended to leave your camera and microphone off unless you are posing a question or taking share in the discussion. Attendance will not be monitored during the live-discussion session of each lecture. You are asked to attend and take share in the discussion if you have any question in the lecture content or the course in general. Live-discussion sessions may be recorded to share common concerns. Please review the Session Recording section. You can also use the Zoom online hours (Mondays 10:00 AM to 11:00 AM) to share any question or concern related to the course materials.

Quizzes:

An online 15-mins quiz will be conducted through cuLearn every other week according to the following schedule. Quizzes will open 6 hours before the lecture time and close immediately before the scheduled lecture time happening on the same day. Quizzes will be drawn from a large question bank while shuffling the order of questions as well as the answers to each question. Quizzes are used as a learning tool to partition the course material into small segments. Each quiz will cover only the 4 lectures following the previous quiz (except for Quiz 3 which covers only 3 lectures due to the Midterm).

- Quiz 1 covers lectures Sept. 10 to Sept. 22
- Quiz 2 covers lectures Sept. 24 to Oct. 6
- Midterm covers all the previous lectures (Sept. 10 to Oct. 20). No lecture on the Midterm Day Oct. 22.
- Quiz 3 covers lectures Nov. 3 to Nov. 10
- Quiz 4 covers lectures Nov. 12 to Nov. 24
- Quiz 5 covers lectures Nov. 26 to Dec. 8

	Tuesday	Thursday
1		Sept. 10 Lect.
2	Sept. 15 Lect.	Sept. 17 Lect.
3	Sept. 22 Lect.	Sept. 24 Quiz 1 + Lect
4	Sept. 29 Lect.	Oct. 1 Lect.
5	Oct. 6 Lect.	Oct. 8 Quiz 2 + Lect.
6	Oct. 13 Lect.	Oct. 15 Lect.
7	Oct. 20 Lect.	Oct. 22 Midterm (No Lect.)
8	Oct. 26 to Oct. 30 Fall Break	
9	Nov. 3 Lect.	Nov. 5 Lect.
10	Nov. 10 Lect.	Nov. 12 Quiz 3 + Lect.
11	Nov. 17 Lect.	Nov. 19 Lect.

12	Nov. 24 Lect.	Nov. 26 Quiz 4 + Lect.
13	Dec. 1 Lect.	Dec. 3 Lect.
14	Dec. 8 Lect.	Dec. 10 Quiz 5 + Review Lect.

Labs:

Labs are expected to require three hours of work every other week. There will be a total of 5 lab sessions in the semester according to the following schedule. Some lab sessions are skipped and marked with a "(no lab)" to accommodate that Friday Dec. 11th follows a Monday schedule. Lab materials will be posted one week ahead of the scheduled lab time. You are recommended to go through and try to complete the lab work on your own schedule before the scheduled lab time. During the scheduled lab time, TAs will use the first 30 mins of the lab time as an open discussion on a Zoom meeting to go through any difficulty with the lab work. Attendance will not be monitored during the first 30-mins open discussion. You are asked to attend and take share in the discussion if you encounter any problem in completing the lab work. Then, every student will have a short one-on-one Zoom meeting with the TA to review the completed lab work, discuss answers to the last Quiz/Midterm, and review learning goals. Attendance of these short meetings will be monitored and counted toward 25% of the lab grade. Scheduling of the one-on-one lab meeting time will be managed by the TAs once they are assigned to the course.

- Full attendance to the assigned lab sessions is mandatory. Only work submitted and discussed during the one-on-one meeting will be marked.
- Your answers to the last Quiz and/or Midterm will also be discussed and counted toward the lab grade.
- If one lab is missed, with a valid medical reason, a mark equal to the average of the other labs will be given. Further absences will result in a mark of zero for the missed labs unless valid documentation of a prolonged illness is provided.
- There are no make-up labs.
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Week	LAB	Tuesday	Thursday	Friday
1			First lecture	
2		Sept. 15 (no lab)	Sept. 17 (no lab)	Sept. 18 (no lab)
3	Lab #1	Sept. 22 L1E	Sept. 24 L3E	Sept. 25 L2E
4		Sept. 29 L1O	Oct. 1 L3O	Oct. 2 L2O
5	Lab #2	Oct. 6 L1E	Oct. 8 L3E	Oct. 9 L2E
6		Oct. 13 L1O	Oct. 15 L3O	Oct. 16 L2O
7	Lab #3	Oct. 20 L1E	Oct. 22 L3E	Oct. 23 L2E
8		Oct. 26 to Oct. 30 Fall Break		
9		Nov. 3 L1O	Nov. 5 L3O	Nov. 6 L2O

10	Lab #4	Nov. 10 L1E	Nov. 12 L3E	Nov. 13 L2E
11		Nov. 17 L1O	Nov. 19 L3O	Nov. 20 L2O
12	Lab #5	Nov. 24 L1E	Nov. 26 L3E	Nov. 27 L2E
13		Dec. 1 L1O	Dec. 3 L3O	Dec. 4 L2O
14		Dec. 8 (no lab)	Dec. 10 (no lab)	

Midterm:

Midterm exam will be online through cuLearn during the scheduled lecture time on Thursday Oct. 22. Exam duration will be one and half hours. The exam will be available on cuLearn by the starting of lecture time (2:30 pm) and closed by the end of the lecture time (4:00 pm). You can start the exam on your own schedule anytime between 2:30 pm and 4:00 pm and continue for the specified exam duration.

- Midterm will cover all the lectures Sept. 10 to Oct. 20. No lecture on the Midterm Day Oct. 22.
- Please expect a relatively long exam with many bonus questions.
- Quizzes will be drawn from a large question bank while shuffling the order of questions as well as the answers to each question.
- The order of questions appear on the exam may not follow the order of topics in the course.
- Midterm exam is used as an education tool. After the exam is complete and graded for everyone, you will be able to review your answers and discuss the grad

Final exam:

Final exam will be online during the formal examination period managed by Exam Services. Final exam duration will be three hours.

- Final exam will cover the entire course.
- Please expect a relatively long exam with many bonus questions.
- Quizzes will be drawn from a large question bank while shuffling the order of questions as well as the answers to each question.
- The order of questions appear on the exam may not follow the order of topics in the course.
- 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. Introduction.
2. Information representation.
3. Digital systems and binary numbers.
4. Basic logic gates and Boolean Algebra.

5. Gate-level minimization.
6. Combinational logic.
7. Combinational logic (cont.).
8. Sequential circuits: Latches and flip-flops.
9. Synchronous sequential circuits: Finite state machines.
10. Synchronous sequential circuits: Counters, Registers, Memory.
11. Asynchronous circuits.
12. Course review.

Important Information

Session Recording

Web conferencing sessions in this course may be recorded and made available only to those within the class. Sessions may be recorded to enable access to students with internet connectivity problems, who are based in different time zone, and/or who have conflicting commitments. If students wish not to be recorded, they need to leave your camera and microphone turned off.

You will be notified at the start of the session when the recording will start, and Zoom will always notify meeting participants that a meeting is being recorded. It is not possible to disable this notification.

Please note that recordings are protected by copyright. The recordings are for your own educational use, but you are not permitted to publish to third party sites, such as social media sites and course materials sites. You may be expected to use the video and/or audio and/or chat during web conferencing sessions for participation and collaboration. If you have concerns about being recorded, please email me directly so we can discuss these.

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

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