ECE253H1 F

Digital and Computer Systems

Fall 2023 Syllabus

Course Meetings

ECE253H1 F

Section	Date & Time	Delivery Mode & Location
LEC0101	Monday, 2:00 PM - 3:00 PM Tuesday, 1:00 PM - 2:00 PM Friday, 1:00 PM - 2:00 PM	In Person: SF 1105 In Person: SF 1101 In Person: BA 1160
LEC0102	Monday, 5:00 PM - 6:00 PM Tuesday, 3:00 PM - 4:00 PM Thursday, 11:00 AM - 12:00 PM	In Person: BA 1130 In Person: BA 1130 In Person: BA 1130
PRA0101	Monday, 3:00 PM - 6:00 PM Monday, 3:00 PM - 6:00 PM Monday, 3:00 PM - 6:00 PM	In Person: BA 3155 In Person: BA 3165 In Person: BA 3145
PRA0102	Monday, 12:00 PM - 3:00 PM Monday, 12:00 PM - 3:00 PM Monday, 12:00 PM - 3:00 PM	In Person: BA 3155 In Person: BA 3165 In Person: BA 3145

We will endeavour to livestream and record these sessions via Zoom and they will be posted to Quercus within 24 hours of completion. You can find links to the livestream and the videos on Quercus.

Masking. We encourage masking for all in-person attendance. Staying healthy is an important part of thriving academically.

Lecture etiquette. If you are joining the livestream, please keep yourself on mute. You can use the livestream Zoom chat for questions but the professor may not be able to take online questions during lecture. You can also post your question to the Piazza Discussion Board to be taken up after lectures.

Class attendance is optional but strongly recommended. Please do not you attend lecture if you are feeling unwell. Recorded and/or livestream lecture materials will be made available to you.

If there are circumstances that prevent you from attending in person, please make every effort to participate remotely and discuss any concerns you have with your instructor via email or an online meeting.

Course Contacts

Course Website: https://q.utoronto.ca/courses/324398

Instructor: Prof. Natalie Enright Jerger
Email: enright@ece.utoronto.ca
Office Hours and Location: Office hours TBD
or by appointment (Book here: https://calendly.com/natalie-enrightjerger)

Instructor: Prof. Mark Jeffrey
Email: mark.jeffrey@utoronto.ca

Course Email: Teaching Team
Email: ece253@ece.utoronto.ca
Additional Notes: Please see email policy for more information.

Course Overview

Digital system design principles. Logic circuits, logic synthesis. Registers, arithmetic circuits, counters, finite state machines, and programmable logic devices. Verilog hardware description language. Computer structure, machine language instruction execution and sequencing, addressing techniques. Processors, input/output techniques, and memory hierarchy. The laboratory work consists of exercises involving the design of logic circuits, and microprocessor systems. Modern computer-aided design tools and FPGA technology are used. Design aspects constitute a major portion of laboratory work.

Digital Logic: Parts A, B, and C. Digital systems underpin many facets of our daily lives from smart phones to thermostats to home security systems. This course will introduce all of the fundamentals needed to design your own digital systems. Starting from the building block of transistors as basic switches, we will cover basic logic gates and logic circuits. From here, we will introduce digital circuits to store information and finite state machines to control the operation of our logic circuits. Through- out the labs associated with this part of the course, you will use the Verilog Hardware Description Language to implement and test digital designs.

Computer Organization: Parts D and E. Although you can build custom logic implementations, most digital systems use processors or microcontrollers to execute their functionality. A processor is simply one incarnation of a digital system that can perform any task as instructed via software. In previous courses, you have learned to program in high-level language such as C or Java. Languages such as C are designed to be human readable. Programs written in these languages get compiled into machine code (assembly language) to be understandable by computers. This portion of the course will deal with how to program in assembly language and how to communicate with input and output devices such as LED lights and switches.

Course Learning Outcomes

You will become knowledgeable in various concepts in Digital Logic and Computer Organization as outlined in the list of modules on Quercus. This means that upon successful completion of this course:

- You will gain an understanding of how information is represented in processors and digital logic systems.

- You will understand how to design logic circuits from simple ones to complex ones.You will be able to take a text description of a circuit's functionality and build the final, optimized circuit design.

- You will be able to design and use digital logic storage elements in your design including flip flops and registers.

- You will be able to design and build a digital logic implementation of finite state machines (FSMs) that can control the operation of your digital logic circuits.

- You will understand how the logic circuits, storage elements and FSMs can be combined to design a processor.

- You will understand how a high-level language gets compiled into assembly language and then assembled into machine code to be executed on a processor.

- You will be able to program proficiently in RISC-V assembly language including how to execute conditional statements, subroutines, and communicate with input/output (I/O) devices.

- You will understand the appropriate use of polling and interrupts for dealing with external inputs to the processor. You will be able to write assembly language programs that implement polling and interrupts.

- We will have trained you in the art of problem solving and design. In your future career as an engineer, you will see problems that you have not encountered before. Through this course, you should be able to figure out how to modify what you know to solve new problems. Problem solving and design skills are broadly applicable even if you do not continue in the area of computer engineering. Your goal should be application of knowledge and not memorization of specific techniques.

Prerequisites: None
Corequisites: None
Exclusions: ECE241H1
Recommended Preparation: None
Credit Value: 0.5
Graduate Attributes:
- 1D. Knowledge Base for Engineering: Demonstrate competence in engineering fundamentals. [Developed]
- 4D. Design: Demonstrate ability to advance an engineering design to a defined end state. [Developed]
- 5A. Use of Engineering Tools: Demonstrate ability to use fundamental modern techniques, resources and engineering tools. [Developed]

- 5C. Use of Engineering Tools: Show recognition of limitations of the tools use. [Developed]

Course Materials

This course uses material from the following textbook

- Digital Design and Computer Architecture, RISC-V Edition, by Harris and Harris, Morgan Kaufmann
- Online supplementary material is available on the publishers' webpage: https://www.elsevier. com/books-and-journals/book-companion/9780128200643

This book is strongly recommended but not required.

Marking Scheme

Assessment	Percent	Details	Due Date
Midterm	30%	There will be 1 midterm. Details on the location and topics covered on the midterm will be presented in lecture and posted on Quercus prior to the midterm.	2023-10-12
Lab assignments	25%		2023-09-28,2023-10-05,2023-10-19,2023-10-26,2023-11-02,2023-11-16,2023-11-23,2023-11-30,2023-12-04
Final Assessment	45%	Details on the final exam will be shared in lecture and via Quercus prior to the exam period.	Final Exam Period

Missed Evaluations

The petition policy of the Faculty of Applied Science and Engineering can be found here:

http://uoft.me/petitions

Do not wait to read these rules until an issue (like illness) arises. Read them now so that if things actually happen, you already know how to proceed.

It is an academic offence to feign illness to skip any course work.

Any foreseeable circumstances must be reported at least three weeks in advance. For example, "I had another test yesterday" is unacceptable. As soon as you know about scheduled events you should look at your academic obligations and notify us of conflicts.

If you miss any course work and you do not submit a petition, or your petition was deemed invalid by the Faculty, you receive a grade of zero for that assessment.

If submit any course work late and you do not submit a petition, or your petition was deemed invalid by the Faculty, you will receive a grade according to the late submission policy. If you submit late and have a valid petition, no late penalty will be assessed.

TAs are not authorized to give any kind of accommodation; if you request an accommodation from a TA, they will instruct you to contact your instructor.

Midterm

If you miss the midterm test and your petition is deemed valid, the weight of the midterm will be shifted to the final exam (the final exam will be worth 75%).

Labs

If you miss lab assignment(s) and your petition(s) was deems valid, your lab mark will be evenly distributed across to all non-petitioned lab assignments. Your total lab mark will remain 25% and the weight for the missed lab will be distributed to the remaining labs. If 5 or more labs are missed, the weight of the missed labs will be shifted to the final exam. If you miss a lab, you are still responsible to know the material from the lab as it will appear on the midterm test and/or final exam.

There are 9 practical laboratory exercises (labs) in this course. We will drop the lowest lab grade of the 9 labs. All necessary hardware will be provided in lab. Lab work can be completed at home without any additional hardware purchases. If you wish to purchase your own FPGA board for the labs, information on how to do so will be provided on Quercus at the beginning of the term. Labs will be completed in **groups of 2**. You will find a partner the first week of lab and must keep the same partner throughout the semester.

Labs will begin Monday September 25. You can use your scheduled practical sessions to get assistance from the TA. TAs may also provide some tutorial material at the start of some practical sessions. Some pre-recorded versions of lab tutorial material may also be provided to you. A portion of your lab mark will be based on answering questions posed by the TA during the lab session.

Labs will be due electronically by 8pm on Thursday of each week.

25% of your mark will be based on 9 laboratory assignments. Each lab is given equal weight and we will drop the lowest lab mark.

Labs will be assessed via a combination of in-lab demos and electronically submitted code that will be marked using an automarker. Labs will be done in pairs but both partners must submit the lab. Partners may have identical lab files (this will not be flagged as academic misconduct). Copying lab files from another group is considered academic misconduct.

Late Assessment Submissions Policy

If you miss the lab submission deadline, you can submit late with a 10% grade penalty per day for each day that submission up to four days after the submission due date.

Course Schedule

Module	Topic	Class hours (approx)	Textbook reference
A	**Introduction to Digital Logic**		
A1	**Information Representation, Number Conversion, Binary Addition**	1	Chapter 1.1-1.4
A2	**Introduction to Logic Operations**	1	1.5
A3	**Introduction to Boolean Algebra**	2	2.1-2.3
A4	**Example Logic Functions**	1	2.4, 2.8, 5.2.1*
A5	**Karnaugh Maps**	2	2.6-2.7
A6	**Introduction to FPGAs and Verilog**	1	4.1-4.2, 4.5.1-4.5.2, 5.6.2
A7	**Timing Analysis (covered at end of term)**	1	2.9
B	**Digital Storage Elements**		
B1	**Latches**	1	3.1-3.2.2
B2	**Flip-Flops**	1	3.2.2-3.2.3
B3	**Counters and registers**	1	3.2.4, 5.4
B4	**Resets and Enables**	1	3.2.5-3.2.6, 4.4
C	**Finite State Machines (FSMs)**		
C1	**Intro to FSMs**	1	3.4-3.4.1
C2	**State assignment**	1	3.4.2
C3	**Verilog for FSMs**	1	4.6
D	**Introduction to Computer Organization and Assembly Language**		
D1	**Intro to Processors**	1	6.1
D2	**Signed Numbers**	1	1.4.6
D3	**Instruction Set Architecture**	1	6.2
D4	**Basic Instruction Execution**	1	6.2, 6.3.2-6.3.3

E	Advanced Assembly Language		
E1	Subroutines	1	6.3
E2	I/O Devices	1	6.5, 9.1-9.2 **
E3	Interrupts	2	6.6, 9.3 **

* Ripple Carry Addition only

** Chapter 9 is available as part of the online supplement to the textbook.

Policies & Statements

University Land Acknowledgement

I wish to acknowledge this land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca, and the Mississaugas of the Credit. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Learn more about Canada's relationship with Indigenous Peoples here.

Indigenous Students' Supports
If you are an Indigenous engineering student, you are invited to join a private Discord channel to meet other Indigenous students, professors, and staff, chat about scholarships, awards, work opportunities, Indigenous-related events, and receive mentorship. Email Professor Bazylak or Darlee Gerrard if you are interested.

Indigenous students at U of T are also invited to visit First Nations House's (FNH) Indigenous Student Services for culturally relevant programs and services. If you want more information on how to apply for Indigenous specific funding opportunities, cultural programs, traditional medicines, academic support, monthly social events or receive the weekly newsletter, go to the FNH website, email or follow FNH on social media: Facebook, Instagram, or TikTok. A full event calendar is on the CLNX platform. Check CLNX often to see what new events are added!

Wellness and Mental Health Support

As a university student, you may experience a range of health and/or mental health challenges that could result in significant barriers to achieving your personal and academic goals. The University of Toronto and the Faculty of Applied Science & Engineering offer a wide range of free and confidential services that could assist you during these times.

As a U of T Engineering student, you have a Departmental Undergraduate Advisor or a Departmental Graduate Administrator who can support you by advising on personal matters that impact your academics. Other resources that you may find helpful are listed on the U of T Engineering Mental Health & Wellness webpage, and a small selection are also included here:

- [U of T Engineering's Mental Health Programs Officer](#)
- [Accessibility Services](#) & the [On-Location Advisor](#)
- [Health & Wellness](#) and the [On-Location Health & Wellness Engineering Counsellor](#)
- [Graduate Engineering Council of Students' Mental Wellness Commission](#)
- [SKULE Mental Wellness](#)
- [U of T Engineering's Learning Strategist](#) and [Academic Success](#)
- [Registrar's Office](#) and [Scholarships & Financial Aid Office & Advisor](#)

We encourage you to access these resources as soon as you feel you need support; no issue is too small.

If you find yourself feeling distressed and in need of more immediate support, consider reaching out to the counsellors at [U of T Telus Health Student Support](#) or visiting U of T Engineering's [Urgent Support – Talk to Someone Right Now](#).

Accommodations

The University of Toronto supports accommodations for students with diverse learning needs, which may be associated with mental health conditions, learning disabilities, autism spectrum, ADHD, mobility impairments, functional/fine motor impairments, concussion or head injury, visual impairments, chronic health conditions, addictions, D/deaf, deafened or hard of hearing, communication disorders and/or temporary disabilities, such as fractures and severe sprains, or recovery from an operation.

If you have a learning need requiring an accommodation the University of Toronto recommends that students [register with Accessibility Services](#) as soon as possible.

We know that many students may be hesitant to reach out to Accessibility Services for accommodations. The purpose of academic accommodations is to support students in accessing their academics by helping to remove unfair disadvantages. We can assess your situation, develop an accommodation plan with you, and support you in requesting accommodation for your course work. The process of accommodation is private; we will not share details of your needs or condition with any instructor.

If you feel hesitant to register with us, we encourage you to reach out for further information and resources on how we can support. It may feel difficult to ask for help, but it can make all the difference during your time here.

Phone: 416-978-8060
Email: accessibility.services@utoronto.ca

Equity, Diversity and Inclusion

Looking for community? Feeling isolated? Not being understood or heard?

You are not alone. You can talk to anyone in the Faculty that you feel comfortable

approaching, anytime – professors, instructors, teaching assistants, first-year or upper years academic advisors, student leaders or the Assistant Dean of Diversity, Inclusion and Professionalism.

You belong here. In this class, the participation and perspectives of everyone is invited and encouraged. The broad range of identities and the intersections of those identities are valued and create an inclusive team environment that will help you achieve academic success. You can read the evidence for this approach here.

You have rights. The University Code of Student Conduct and the Ontario Human Rights Code protect you against all forms of harassment or discrimination, including but not limited to acts of racism, sexism, Islamophobia, antisemitism, homophobia, transphobia, ableism, classism and ageism. Engineering denounces unprofessionalism or intolerance in language, actions or interactions, in person or online, on- or off-campus. Engineering takes these concerns extremely seriously and you can confidentially disclose directly to the Assistant Dean for help here.

Resource List:

- Engineering Equity, Diversity & Inclusion Groups, Initiatives & Student Resources
- Engineering Positive Space Resources
- Request a religious-based accommodation here
- Email Marisa Sterling, P.Eng, the Assistant Dean, Diversity, Inclusion & Professionalism here
- Make a confidential disclosure of harassment, discrimination or unprofessionalism here or email engineering@utoronto.ca or call 416.946.3986
- Email the Engineering Society Equity & Inclusivity Director here
- U of T Equity Offices & First Nations House Resources

Quercus Information

This course uses the University's learning management system, Quercus, to post information about the course. This includes posting readings and other materials required to complete class activities and course assignments, as well as sharing important announcements and updates. The site is dynamic and new information and resources will be posted regularly as we move through the term, so please make it a habit to log in to the site on a regular, even daily, basis. To access the course website, go to the U of T Quercus log-in page at https://q.utoronto.ca. Once you have logged in to Quercus using your UTORid and password, you should see the link or "card" for this course. You may need to scroll through other cards to find this. Click on this link to open our course area, view the latest announcements and access your course resources.There are Quercus help guides for students that you can access by clicking on the "?" icon in the left side column.

SPECIAL NOTE ABOUT GRADES POSTED ONLINE: Please also note that any grades posted are for your information only, so you can view and track your progress through the course. No grades are considered official, including any posted in Quercus at any point in the term, until

they have been formally approved and posted on ACORN at the end of the course. Please contact me as soon as possible if you think there is an error in any grade posted on Quercus.

Academic Integrity

All students, faculty and staff are expected to follow the University's guidelines and policies on academic integrity. For students, this means following the standards of academic honesty when writing assignments, collaborating with fellow students, and writing tests and exams. Ensure that the work you submit for grading represents your own honest efforts. Plagiarism—representing someone else's work as your own or submitting work that you have previously submitted for marks in another class or program—is a serious offence that can result in sanctions. Speak to me or your TA for advice on anything that you find unclear. To learn more about how to cite and use source material appropriately and for other writing support, see the [U of T writing support website](). Consult the [Code of Behaviour on Academic Matters]() for a complete outline of the University's policy and expectations. For more information, please see the [U of T Academic Integrity website]().

Cell Phones and Laptop Usage

Technology can support student learning, but it can also become a distraction. Research indicates that multi-tasking (texting, surfing the Internet, using social networks) during class time can have a negative impact on learning (Clapp, Rubens, Sabharwal & Gazzaley, 2011; Ellis, Daniels, Jauregui, 2010; Hembrooke & Gay, 2003). Out of respect for your fellow learners in this class, please refrain from using laptops or mobile phones for entertainment during class and do not display any material on a laptop which may be distracting or offensive to your fellow students. Laptops may be used only for legitimate classroom purposes, such as taking notes, downloading course information from Portal, or working on an assigned in-class exercise. Checking social media, email, texting, games, and surfing the Web are not legitimate classroom purposes. Such inappropriate laptop and mobile phone use is distracting to those seated around you.

Lecture Capture by Instructor

If lecture recordings are provided, they are only for the exclusive use of enrolled students, for their personal learning. Lecture recordings are not to be shared in any way beyond enrolled students.

Video Recording and Sharing (Download Permissible; Re-use Prohibited)

This course, including your participation, will be recorded on video and will be available to students in the course for viewing remotely and after each session.

Course videos and materials belong to your instructor, the University, and/or other sources depending on the specific facts of each situation and are protected by copyright. In this course, you are permitted to download session videos and materials for your own academic use, but you should not copy, share, or use them for any other purpose without the explicit permission of the instructor.

For questions about the recording and use of videos in which you appear, please contact your instructor.

Generative AI

Students may use artificial intelligence tools, including generative AI, in this course as learning aids or to help produce assignments. However, students are ultimately accountable for the work they submit. If students use generative AI, they must disclose this in their assignment submission and provide the prompts they inputted to the generative AI (prompts should be included as comments at the beginning of your submitted code). Generative AI cannot be used on tests or exams. Finally, we advise against the use of generative AI, as it does not help you learn the material and you will be required to write code on tests and exams without the aid of these types of tools.

Additional Content

Email policy

1. You should use your @mail.utoronto.ca for all course related communications. Your @mail.utoronto.ca email address is the most efficient way for us to know you are enrolled as a student in the course.

2. You must include ECE253 in the email subject.

3. If you have a question about the course policies, check the syllabus. Then check the syllabus again. If you still didn't find your answer, please email the teaching team at ece253@ece.utoronto.ca. The appropriate member of the teaching team will respond to your request.

4. If you are considering emailing a question about the course concepts, you are encouraged to instead post that question to the course Piazza Discussion page. By posting your question to Piazza Discussion, you allow your peers to also learn from your question (and the resulting answer provided by the teaching team). If you email a question that the rest of the class would benefit from, the instructors may post your question to Piazza Discussion anonymously.

5. You should not expect a response to email outside of regular working hours. Setting boundaries and maintaining a work-life balance is important. We will do our best to respond to email within 2 business days.

Online Discussion

In this course, we will use Piazza Discussion as our discussion board. Piazza Discussion has been integrated as a tool in Quercus. You can navigate to the Piazza Discussion page for the course from the links on the left-hand side of the Quercus page for this course.

Please do not use email for questions regarding course concepts. Instead, please post such questions on Piazza Discussion. That way, everyone can chime in and learn from your questions. You will likely get a faster response via Piazza Discussion than via email.

Of course, you are welcome to ask us during lecture and drop-in hours. We are always happy to answer student questions but we find email is not the most efficient way to do this.

Please do not email your TA unless they specifically asked you to do so.

How to learn in this course

	hours/week	
	contact	self-study
Pre-class essentials. Learn the basics through self-study. Before each in-person session, you are recommended to review the reading associated with the lecture topics. By reading in advance, you will be prepared for the material as it is covered in lecture. Prior to lecture, you are **strongly encouraged** to complete the quiz to gauge your own under- standing and to provide feedback to the instructor on what concepts need more attention in the in-person sessions.	0	1
In-Person/Synchronous Lecture Sessions. Dive Deeper. Synchronous lecture sessions will take place in person. The instructor will cover concepts from the readings and solve example problems. Synchronous lectures will follow the convention of "UofT time" and start at 10 past the hour. **Attending these sessions is strongly recommended.** The synchronous session is your chance to directly engage with your instructor and to tap into their expertise. Do not miss out on class. The exception to this is if you are ill, for your own good and the good of your class community, please stay home. **Unable to attend in person?** Lectures will be recorded and posted on Quercus.	3	0
Studying. Solidify your knowledge through review Based on the readings and lecture sessions, you will have an idea which concepts are clear to you and which you should work on. There are resources at your disposal to help you study: You can find suggested problems in the textbook and on past exams. You can ask questions on the course's Piazza Discussion page and of course you can come to Drop-In Hours to get help. **Study smart.** Your learning experience in this course will improve dramatically if you follow a schedule that distributes the load across your twelve weeks, rather than falling behind and trying to catch up right before exams. Keep up with the schedule provided.	mileage varies *	

Online/In-Person Drop-In Hours. Hang out and get help with course material Your instructor will host 1 hour of drop-in sessions per week via Zoom or in-person. This is an informal session with limited structure. It is an opportunity for you to connect with your instructor and your peers. Bring your questions from the course material. We can also chat about how the term is going and any general questions you have. If you would like to discuss a more personal matter (e.g., illness, accommodation, etc.), it is recommended that you book an individual appointment with your instructor instead of using Drop-In Hours. **Drop-in Hours are an open space.** You can also just hang out, study and chat with others. Your questions and concerns are important to the teaching team and we don't think your question is dumb.	1	0
Lab Assignments. Apply your knowledge. Lab assignments should take 4-6 hours to complete. Your TAs will be available during designated lab sessions to answer questions. You are to complete your labs in pairs and you will individually submit this work electronically for marking. You will also be required to answer in-lab questions posed by the TA for a portion of the lab marks. Labs apply the knowledge taught in lecture and are essential to solidifying your understanding of the course material. **Labs require a considerable time investment.** Do not underestimate the amount of time labs will take. Start early.	3	3

* The time you need depends on your own learning experience. However, in total you should spend ~10 hours per week on this course.