**Western University**
**Faculty of Engineering**
**Department of Electrical and Computer Engineering**

# ECE 2277A: Digital Logic Systems

## Course Outline 2023-2024

This course introduces students to design and analysis of digital electronic devices. Students will learn fundamental concepts of digital systems and apply those concepts to design problems. Three themes are emphasized: representation of digital processes using algorithms, a modular approach to design by partitioning complex systems into subsystem hierarchies, and hardware implementation and use of programmable devices.

**Academic Calendar Copy:** Theory of Boolean algebra, switching circuits, Venn diagrams; Karnaugh maps; logic and memory systems, design of combinational and sequential switching machines; electronic switching circuits; data coding, storage, transmission; basic design of digital computers.

**Contact Hours:** 3 lecture hours, 1 laboratory hours, 1 tutorial hours, 0.5 course.

**Antirequisite:** the former ECE3339A/B

**Prerequisites:** Physics 1302 A/B or Physics 1402A/B or the former Physics 1026.

**Corequisite(s):** ECE 2205A/B or registration in Integrated Engineering or Software Engineering Program.

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

**CEAB Academic Units:** Engineering Science 75%, Engineering Design 25%.

**Required Textbook:** M.M. Mano and M.D. Ciletti, *Digital Design: With an Introduction to the Verilog HDL, VHDL, and SystemVerilog*, 6th ed., Pearson, 2018, ISBN: 9780134549897.
Please note that there are three options for purchasing the textbook from Western's bookstore:

- A traditional printed copy (ISBN 9780134549897).

- An electronic copy with a perpetual digital license (ISBN 9780134529578). This provides you with electronic access to the textbook for the rest of your life.
- An electronic copy with a subscription digital license (ISBN 9780134529561). This is the least expensive option and provides you with electronic access to the textbook for 180 days. (Longer if you renew your subscription.)

It is only required to purchase the textbook using **one** of these options.

**Other Required References:** Lab manual documents available on the course OWL site.

**Recommended References:** See links on course OWL site.

**General Learning Objectives (CEAB Graduate Attributes)**

| | | | | | |
|---|---|---|---|---|---|
| Knowledge Base | I | Use of Engineering Tools | I | Impact on Society and the Environment | |
| Problem Analysis | I | Individual and Team Work | | Ethics and Equity | |
| Investigation | | Communication Skills | | Economics and Project Management | |
| Design | D | Professionalism | | Life-Long Learning | |

Notation*: where x be I: Introductory, D: Intermediate, A: Advanced, or empty*. I – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. D – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. A – It is expected that the student can apply the knowledge without prompting (e.g. no review).

| **Course Topics and Specific Learning Outcomes** | **CEAB Graduate Attributes Indicators** |
|---|---|
| **1. Digital Number Systems** | |
| At the end of this section, students will be able to: | |
| **a.** Express numbers in binary, octal, and hexadecimal representations and convert between those number systems and the decimal system. | **PA 1** |
| **b.** Obtain signed magnitude, one's-complement, and two's-complement representations of signed numbers and perform arithmetic in each of those formats. | **PA 1** |
| **2. Boolean Algebra and Logic Gates** | |
| At the end of this section, students will be able to: | |
| **a.** Use the postulates of Boolean algebra to verify complex Boolean expressions. | **PA 1** |
| **b.** Derive a Boolean expression for a logic function given a schematic diagram of a digital circuit that implements the expression. | **PA 1, KB 3** |

| | |
|---|---|
| **3. Gate-Level Minimization** | |
| At the end of this section, students will be able to: | |
| **a.** Use Karnaugh maps and postulates of Boolean algebra to derive optimal implementations of digital logic circuits. | **PA 2, KB 3** |
| **b.** Implement logic functions using a constrained set of logic gates. | **PA 2, PA 3** |
| **4. Combinational Circuits** | |
| At the end of this section, students will be able to: | |
| **a.** Define the logic functions performed by fundamental combinational circuits (multiplexers, encoders, decoders, etc.). | **PA 1, KB 3** |
| **b.** Use fundamental combinational circuit blocks to design and implement circuits that realize more complex functions. | **PA 2, PA 3** |
| **5. Synchronous Sequential Circuits** | |
| At the end of this section, students will be able to: | |
| **a.** Define three types of synchronous flip-flop (D, T, and JK) and give their characteristic and excitation tables. | **PA 1** |
| **b.** Differentiate between Mealy- and Moore-model sequential circuits. | **PA 1, KB 3** |
| **c.** Design and implement a synchronous state machine to perform a sequential logic function given a word description, block diagram, and/or timing diagram of the function. | **PA 2, PA 3, KB 3, D 2, D 4** |
| **d.** Minimize the number of states realized by a synchronous state machine. | **PA 2, KB 3** |
| **6. Registers and Counters** | |
| At the end of this section, students will be able to: | |
| **a.** Define the purpose and function of fundamental sequential circuits (counters, registers, shift registers, etc.). | **PA 1** |
| **b.** Design and implement synchronous sequential circuits using state machine methods and fundamental sequential circuit blocks. | **PA 2, PA 3, KB 3** |
| **7. Implementation of Digital Circuits (Laboratory Exercise)** | |
| At the end of the laboratory exercises, students will be able to: | |
| **a.** Create and verify digital circuit designs using industry-standard design software. | **PA 2, ET 2, D 2, D 4** |
| **b.** Implement and test digital circuits using an FPGA-based development board. | **PA 3, ET 2, D 2, D 4** |

**Evaluation**

| Course Component | Weight |
|---|---|
| Laboratory | 20% |
| Project | 10% |
| Midterm Test | 25% / 0% |
| Final Examination | 45% / 70% |

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination and the laboratory. A final examination or laboratory mark of < 50% will result in a final course grade of 48% or less.

For the midterm test and final examination, the **greater** (25% midterm + 45% final) or (0% midterm + 70% final) will be used to evaluate each student's grade.

**Laboratory:** Four laboratory experiments are to be performed in this course. Information will be posted to the course OWL site. Laboratory exercises consist of designing logic circuits in software, which can be done prior to attending the laboratory session, and then implementing and testing that circuit on a FPGA development board during the laboratory session. Students must submit a lab report by the end of the lab. Attendance in the laboratory is mandatory.

**Project:** Students will be required to design, build, and test a logic circuit on the FPGA development board and write a report. The details of the design requirements for this logic circuit will be distributed in class, at least two weeks before the report and circuit demonstration is due.

**Midterm Test:** The midterm test will be scheduled during the regular academic term; the exact date will be determined later. Students will be notified of the test date through the course OWL site in advance. The midterm test is expected to be an **in-person**, **closed-book** test. A non-programmable calculator may be used, but use of any other electronic device is not permitted during the test. The midterm test is **optional**, if students do not complete the midterm, that portion of their grade will be added to the final examination. If students do complete the midterm, but achieve a higher grade on the final examination than on the midterm, the final examination grade will be used instead.

**Final Examination:** The final examination will take place during the regular examination period. The final examination is expected to be an **in-person**, **closed-book** exam. A non-programmable calculator may be used, but use of any other electronic device is not permitted during the examination.

**Late Submission Policy:** Laboratory reports should be submitted before leaving the laboratory, and project reports should be submitted after demonstrating the circuit. Late submission of these reports is not accepted. Late submission of quizzes may be permitted under extenuating circumstances at the instructor's discretion, but the priority will be to promptly grade, return, and post the answers to the quizzes. No quiz submissions will be accepted after the answers are posted.

**Use of English:** In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

**Attendance:** All laboratories are mandatory unless otherwise stated. Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

**Online Activities:** The course OWL site will be extensively used in delivering course content including announcements, lesson slides, and online quizzes. Some pre-recorded video lessons from last year's remote course delivery will be available as learning aids and to supplement in-class activities. Public distribution of lecture materials including course notes, slides, and video lessons is not permitted.

**COVID-19 Contingency Clause:** In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, all remaining course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any remaining assessments will also be conducted online at the discretion of the course instructor.

**Absence Due to Illness or Other Circumstances:** Students should immediately consult with the instructor or department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached "Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled"). The student should seek advice from the instructor or department Chair regarding how best to deal with the problem. Failure to notify the instructor or department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

**Cheating and Plagiarism:** Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com).

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

**Use of Electronic Devices:** Not applicable.

**Use of Personal Response Devices ("Clickers"):** Not applicable.

**Policy on Repeating All Components of a Course:** Students who are required to repeat an Engineering course must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment, or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted by the student for grading in subsequent years.

**Internet and Electronic Mail:** Students are responsible for regularly checking their Western e-mail and the course web site (https://owl.uwo.ca/portal/) and making themselves aware of any information that is posted about the course.

**Accessibility:** Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

**Support Services:** Office of the Registrar, http://www.registrar.uwo.ca/
Student Development Centre, http://www.sdc.uwo.ca/
Engineering Undergraduate Services, http://www.eng.uwo.ca/undergraduate/
USC Student Support Services, http://westernusc.ca/services/

Students who are in emotional/mental distress should refer to Mental Health @ Western, http://www.health.uwo.ca/mental_health/, for a complete list of options about how to obtain help.

## STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, here. To connect with a case manager or set up an appointment, please contact support@uwo.ca.

## INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions listed below. You should understand that academic relief will not be granted automatically on request. You must demonstrate to your department (or the Undergraduate Services Office) that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

### A. *GENERAL REGULATIONS & PROCEDURES*

1. All first-year students will report to the Undergraduate Services Office by submitting the Academic Consideration Request Form, for all instances.

2. If you are an upper year student and you are missing a test/assignment/lab or examination you will report the absence by submitting Academic Consideration Request Form. Absences worth LESS THAN 10% of your mark, will be processed by your department office. If your course work is worth 10% OR MORE of your final grade, your request will be processed by the Undergraduate Services Office.

3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.

4. Documentation must be provided as soon as possible. If no one is available in your department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.

5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

### B. *TERM/MIDTERM TESTS*

1. If you are in first year and you are unable to write a midterm/term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.

2. If you are an upper year student and you are unable to write a midterm/term test, inform your instructor PRIOR to the scheduled date of the test and request relief through the Academic Consideration Request Form. If the instructor is not available, leave a message for him/her at the department office. If the test is worth LESS THAN 10% of your mark, your request for relief will be processed by your department office. If the test is worth MORE THAN 10% of your final grade your request for relief will be processed by the Undergraduate Services Office.

3. Be prepared to attach supporting documentation to the Department Chair and/or the Undergraduate Services Office through the online form (see next page for information on documentation).

4. Discuss with the instructor if and when the test can be rescheduled. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.

## C. *FINAL EXAMINATIONS*

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to report your absence using the Academic Consideration Request Form and request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.

2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.

3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department **and** the Associate Dean and in order to apply you must submit an "Application for a Special Exam" form. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

   ***PLEASE NOTE:*** **It is the student's responsibility to check the date, time and location of the Special Examination.**

## D. *LATE ASSIGNMENTS*

1. Advise the instructor if you are having problems completing the assignment on time (**prior** to the due date of the assignment).
2. Be prepared to submit the Academic Consideration Request Form and provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4. i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.
   ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

## E. *SHORT ABSENCES*

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

## F. *EXTENDED ABSENCES*

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You are strongly encouraged to seek advice from your Academic Counsellor in the Undergraduate Services Office.

## G. *DOCUMENTATION*

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, **you must provide the doctor with a Student Medical Certificate** to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctor's notes will not be accepted; only the Student Medical Certificate will be accepted.**

***In Case of Serious Illness of a Family Member:*** Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

***In Case of a Death:*** Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

***For Other Extenuating Circumstances:*** If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

***Note:*** **Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).**

## H. *ACADEMIC CONCERNS*

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).

2. **You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.**

3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your Academic Counsellor.

***Calendar References:*** Check these regulations in your 2023 Western Academic Calendar available at www.westerncalendar.uwo.ca.

**Absences Due to Illness**:
https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_135

**Academic Accommodations for Students with Disabilities:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_10

**Academic Accommodations for Religious or Holy Days:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16

**Course Withdrawals:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page_75

**Examinations:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=

**Scheduling of Term Assignments:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading_78

**Scholastic Offences:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20

**Student Medical Certificate**:
https://www.eng.uwo.ca/files/undergraduate/student-medical-certificate.pdf

**Engineering Academic Regulations:**
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page_86

***Note:*** These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

| | | |
|---|---|---|
| ***Add Deadlines:*** | First term half course (i.e. "A" or "F") | September 15, 2023 |
| | Full courses and full-year half course (i.e. "E", "Y" or no suffix) | September 15, 2023 |
| | Second term half course (i.e. "B" or "G") | January 16, 2024 |
| ***Drop Deadlines*:** | First term half course without penalty (i.e. "A" or "F") | November 13, 2023 |
| | Full courses and full-year half courses without penalty (i.e. "E","Y" or no suffix) | November 30, 2023 |
| | Second term half or second term full course without penalty (i.e. "B" or "G") | March 7, 2024 |

***Contact Information:***

| | | | |
|---|---|---|---|
| Undergraduate Services Office: | SEB 2097 | Phone: 519-661-2130 | E-mail: engugrad@uwo.ca |
| Chemical & Green Process Engineering: | TEB 477 | Phone: 519-661-2131 | E-mail: cbeugrad@uwo.ca |
| Civil Engineering: | SEB 3005 | Phone: 519-661-2139 | E-mail: civil@uwo.ca |
| Computer, Electrical, Mechatronic Systems & Software Engineering | TEB 279 | Phone: 519-661-3758 | E-mail: eceugrad@uwo.ca |
| Integrated Engineering | ACEB 2410 | Phone: 519-661-6725 | E-mail: engceli@uwo.ca |
| Mechanical Engineering: | SEB 3002 | Phone: 519-661-4122 | E-mail: mmeundergraduate@uwo.ca |