

Western University
Faculty of Engineering
Department of Electrical and Computer Engineering

ECE 3349A: Introduction of VLSI

Course Outline Fall 2023

Description: This course is an introduction to concepts associated with the analysis and design of integrated circuits (IC) in the state-of-the-art CMOS technologies. Continuous advances in microelectronics and Very Large Scale of Integration (VLSI) made an entire electronic system on a single chip (SoC) possible. Modern VLSI ICs contain more than two billion components per chip. Design and manufacturing of semiconductor devices present unique challenges, especially at the conceptual and design levels, therefore computer-assisted design (CAD) methods are sought to help manage these complex designs. In particular, this course introduces CMOS semiconductor devices, physical principles behind IC design, design and analysis of digital logical gates, and the use of professional CAD tools for IC design.

Academic Calendar Copy: <http://www.westerncalendar.uwo.ca>

Contact Hours: 3 lecture hours per week, 3 laboratory hours per week (4 laboratory exercises per term), 0.5 course.

Antirequisite: N/A

Prerequisites: ES1021A/B, ECE2233A/B, ECE2236A/B, ECE2240A/B, ECE2241A/B, ECE2277A/B, ECE2238A/B and successful completion of the second year of the Electrical or Computer Engineering program or Integrated Engineering Program.

Co-requisite: N/A

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: H. E. Neil and D. Harris, *CMOS VLSI Design, A Circuits and Systems Perspective*, Pearson Education, 4th Edition (2011).

Other Required References: Lecture slides, notes, and the laboratory manual will be provided as PDFs and distributed over OWL.

Recommended References: Any further recommended reading will be posted on OWL.

General Learning Objectives (CEAB Graduate Attributes)

Knowledge Base	D	Use of Engineering Tools		Impact on Society and the Environment	
Problem Analysis		Individual and Team Work		Ethics and Equity	
Investigation	A	Communication Skills	A	Economics and Project Management	
Design		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
<p>1. Semiconductor Devices and Technology: Section covers electrical properties of doped silicon; NMOS, PMOS, and CMOS architectures; and an overview of IC fabrication.</p> <p>At the end of this section, students will be able to:</p> <ol style="list-style-type: none"> Understand the physical and engineering principles behind semiconductor technology. Understand CMOS processing steps. 	<p>KB3</p> <p>KB3, CS1</p>
<p>2. CMOS Logic: Section covers basic CMOS logic circuits; compound gates; signal strength and propagation; CMOS latches and flip-flops; timing and clock skew; gate layout; and stick diagrams.</p> <p>At the end of this section, students will be able to:</p> <ol style="list-style-type: none"> Understand theoretical principles behind CMOS logic gates. Understand CMOS circuits and layouts. Design and test functionality of basic gates by using CAD tools. 	<p>KB3</p> <p>KB3</p> <p>I2</p>
<p>3. MOS Transistor Theory: Section covers current-voltage operation of MOS transistors; real-world effects and capacitance; channel formation; operation in cutoff, linear, and saturation regions; DC response and load-line analysis; DC transfer curves; noise margins; and logic levels.</p> <p>At the end of this section, students will be able to:</p> <ol style="list-style-type: none"> Understand theoretical principles behind MOS device operation. Understand practical engineering issues related to MOS device design. Solve basic MOS circuits using simple models for MOS operation. 	<p>KB3</p> <p>KB3</p> <p>KB3</p>

4. Transient Response: Section covers transient response of MOS transistors; propagation delays; rise and fall times; simple models of MOS delay; and small signal analysis using equivalent circuits.

At the end of this section, students will be able to:

- a. Understand DC and transient response of transistors.
- b. Solve transient response of basic MOS circuits using simple models and equivalent circuits.

KB3

KB3

5. Logical Effort: Section covers delay models to inform chip design; logical and electrical effort; delay paths in multistage networks; designing fast circuits; selecting optimal number of stages in a multistage circuit; and stage effort sensitivity analysis.

At the end of this section, students will be able to:

- a. Understand delay, logical effort, and principles of designing fast ICs.
- b. Solve for the delay in multistage networks.
- c. Design optimized multistage circuits.

KB3

KB3, I2

I2

6. Power: Section covers instantaneous and average power; heat dissipation; switching waveforms; dynamic power reduction; activity factors and techniques for estimating them; sources of power leakage; and static power.

At the end of this section, students will be able to:

- a. Understand different sources of power dissipation.
- b. Solve for power consumption of ICs.
- c. Design low-power ICs.

KB3

KB3

KB3

7. Combinational and Sequential Circuit Design: Section covers bubble pushing; compound gates; different circuit families; sequencing for static and dynamic circuits; and circuit design of latches and flip-flops.

At the end of this section, students will be able to:

- a. Understand techniques to optimize combinational circuits for lower delay and/or power.
- b. Understand sequencing for both static and dynamic circuits.
- c. Understand circuit families and design of latches and flip-flops.

KB3

KB3

KB3

8. Circuit Simulation: Section covers modeling and simulating circuits using Cadence and SPICE; verifying IC operation; and designing ICs for specific performance requirements. This course topic will be primarily addressed in the laboratory exercises.

At the end of this section, students will be able to:

- a. Synthesize and analyze a basic digital logic IC.
- b. Design and verify IC operation using Analog Cadence tools and a SPICE simulator.

I2

I2

Evaluation

Course Component	Weight
Homework Assignments	10%
Laboratory	25%
Midterm Test	15%
Final Examination	50%

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

Homework Assignments: Assignments will be regularly announced and posted on the course OWL site. Students must provide their answers on OWL as instructed on the assignment and by the posted due date. These assignments will be problem based.

Laboratory: This course has four lab exercises. The first is an introductory exercise; the laboratory mark is evenly distributed among the remaining three. Labs must be completed individually. Laboratory reports should be submitted online using OWL by the posted due date.

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 and location through the course OWL site with no less than 2 weeks of advance notice. The midterm test will be an in-person, closed-book 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.

Final Examination: The final examination will take place during the regular examination period, as scheduled by the registrar. The final exam will be an in-person, closed-book test. The final examination will cover all content discussed in the lessons. If a student receives a higher grade on their final exam than on their midterm exam, the midterm grade will be discarded, and the final exam grade will be used in its stead.

Late Submission Policy: Homework Assignments should be submitted by the posted deadlines. Accommodations for late submission might be made at student's request (assuming this request is made in a timely manner) at the instructor's discretion. The priority will be marking submitted assignments and posting the answers to OWL reasonably promptly after the assignment deadline as a study aid for students. No late assignments will be accepted, for any reason, after the answers are posted. Students should complete laboratory exercises according to the posted schedule. Students must contact the instructor promptly if they are unable to meet a laboratory submission deadline and seek an accommodation. Laboratory assignments will generally not be accepted after the posted deadline unless an accommodation is granted for exceptional circumstances.

Assignment Submission Locker: Submission of any and all course work (homework, lab reports) will be done online using OWL. A submission locker will not be used.

Academic Consideration: Students who require academic consideration due to medical or personal reasons should alert the instructor of their situation as soon as possible. As all homework assignments and laboratory reports can be completed over an extended period, academic consideration is generally **only** grounds for an extension on submitting that assessment, **not** an excuse for failing to complete that assessment. In particular, **each laboratory exercise must be**

completed, or the student will receive 0% for that exercise. Students with academic consideration can have their lab session rescheduled, but under no circumstances will their grade for that lab exercise be waived. Students under exceptional circumstances (i.e. prolonged leave of absence) may qualify for having the grade of individual homework assessments redistributed or use their final exam grade instead; these will be assessed at the instructor's discretion based on circumstance.

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 (except 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: 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. Attendance may be assessed by the frequency of that student's access to OWL.

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

Missed Midterm Examinations: If a student misses a midterm examination, she or he must follow the Instructions for Students Unable to Write Tests and provide documentation to Undergraduate Services Office within 24 hours of the missed test. If accommodation is granted, the department will provide a make-up test.

If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

Since the midterm is optional, any student who misses the midterm and does not provide a request for accommodation will have that portion of their grade automatically reweighted towards the final exam.

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 website (<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_13_5

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=#Page_78

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