Description: 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.

Instructor: Dr. Duane Jacques  
TEB 380, 519-661-2111 ext. 81267, djacque4@uwo.ca  
Consultation hours: Tuesdays 1pm -3pm

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, 2 laboratory hours, 1 tutorial hours, 0.5 course.

Antirequisite: the former ECE3339A/B

Prerequisites: 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%.


Note: The 5th edition (2013) of the textbook is also acceptable.

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)

<table>
<thead>
<tr>
<th>Knowledge Base</th>
<th>Use of Engineering Tools</th>
<th>Impact on Society and the Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Analysis</td>
<td>Individual and Team Work</td>
<td>Ethics and Equity</td>
</tr>
<tr>
<td>Investigation</td>
<td>Communication Skills</td>
<td>Economics and Project Management</td>
</tr>
<tr>
<td>Design</td>
<td>Professionalism</td>
<td>Life-Long Learning</td>
</tr>
</tbody>
</table>

Notation: $x/y$, where $x$ is the cognitive level (1: Remember, 2: Understand, 3: Apply) at which the attribute is assessed and $y$ is the academic level (1: Beginner, 2: Intermediate, 3: Advanced) at which the attribute is assessed.

Topics and Specific Learning Objectives

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.
   b. Obtain signed magnitude, one’s-complement, and two’s-complement representations of signed numbers and perform arithmetic in each of those formats.

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.
   b. Derive a Boolean expression for a logic function given a schematic diagram of a digital circuit that implements the expression.

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.
   b. Implement logic functions using a constrained set of logic gates.

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.).
   b. Use fundamental combinational circuit blocks to design and implement circuits that realize more complex functions.

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.
b. Differentiate between Mealy- and Moore-model sequential circuits.

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.

d. Minimize the number of states realized by a synchronous state machine.

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.).

b. Design and implement synchronous sequential circuits using state machine methods and fundamental sequential circuit blocks.

c. Use industry-standard FPGA design software to implement digital circuits (this skill will be learned and applied via the laboratory exercises).

7. Implementation of Digital Circuits (laboratory exercises)

At the end of the laboratory exercises, students will be able to:

a. Create and verify digital circuit designs using industry-standard design software (Intel Quartus).

b. Implement and test digital circuits using an FPGA-based development board (Terasic DE10-Standard evaluation board).

Evaluation

<table>
<thead>
<tr>
<th>Course Component</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Lab 1</td>
<td>3%</td>
</tr>
<tr>
<td>Lab 2</td>
<td>4%</td>
</tr>
<tr>
<td>Lab 3</td>
<td>6%</td>
</tr>
<tr>
<td>Lab 4</td>
<td>7%</td>
</tr>
<tr>
<td>Midterm Test #1</td>
<td>15%</td>
</tr>
<tr>
<td>Midterm Test #2</td>
<td>15%</td>
</tr>
<tr>
<td>Final Examination</td>
<td>50%</td>
</tr>
</tbody>
</table>

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 total laboratory component. A final examination or total laboratory component mark < 50% will result in a final course grade of 48% or less.

Homework Assignments: Practice problem sets will be released on the OWL site nearly every week. The problems are only for practice and will not be graded. Solutions for the problem sets will be discussed in the weekly tutorial sessions.

Quizzes: None

Laboratory: The laboratory component consists of four exercises including pre-lab design work that will be posted on OWL. A schedule of the laboratory section meetings will also be posted on the OWL course site. A student’s laboratory mark is determined by the teaching assistant’s evaluation of (I) the written lab report work (including pre-lab design), (II) submission of
design/simulation software files (Labs 1 and 2), and/or a demonstration by the student of properly functioning FPGA implementations of the circuits (Labs 3 and 4). Due dates for each lab exercise are posted on the course OWL site for each specific lab section.

“Choose You Own Adventure” problem structure: some of the lab exercises will be presented as a choice from a set of problems with varying Degree of Difficulty (DoD). Students wishing to take on a more (or less) challenging design problem will have that weighting factor applied to calculation of the grade awarded for the problem submission. Example grading:

<table>
<thead>
<tr>
<th>DoD</th>
<th>Raw Grade</th>
<th>Final Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>8/10</td>
<td>7.2/10</td>
</tr>
<tr>
<td>1.0</td>
<td>8/10</td>
<td>8/10</td>
</tr>
<tr>
<td>1.1</td>
<td>8/10</td>
<td>8.8/10</td>
</tr>
</tbody>
</table>

Midterm Test: Two 90-minute, closed-book midterm tests will take place according to the following schedule. No aids will be permitted during either test. Test seating rosters will be posted on OWL to assign each student to write in one of the rooms listed below.

- **Test 1:** Saturday, October 19th, 2019 at 7pm, in {SH2316, SH2317, SH2355, WSC55, WSC240}.
- **Test 2:** Monday, November 11th, 2019 at 7:30pm in {SSC2028, SSC2036, UCC37, UCC146}.

Final Examination: The final examination will take place during the regular examination period, as scheduled and announced by the Registrar’s Office.

Late Submission Policy: Late submission policy for each laboratory exercise will be declared in the corresponding lab exercise manual. The policy stated in each exercise manual is specific to that exercise and supersedes the general policy statements here, if they differ.

- For laboratory exercises with due dates corresponding to a specific in-lab session, no late submission of is permitted. Students who are absent from laboratory sections should follow the attached “Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled”.
- For laboratory exercises that are designated as “Take Home Exercises” corresponding to a general submission due date, late submissions through the OWL submission link with following penalty schedule:
  - 10% late deduction per day, up to 4 days late.
  - Not accepted beyond 4 days late.

Assignment Submission Locker: Sections 001 & 002
Locker #216 located on the second floor of TEB.

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:** 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.

**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, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation to their department within 24 hours of the missed test. The department will decide whether to allow the reweighting of the test, where reweighting means the marks normally allotted for the midterm will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the 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.

**Missed Lab:** If a student misses their registered laboratory session and receives academic accommodation, they are responsible for contacting the instructor within 48 hours to schedule their attendance at one the remaining, regularly scheduled laboratory sessions to make-up the missed exercise. After this period, the student will receive a grade of zero for the exercise if the lab is not rescheduled.

**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

**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:**  
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.
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.

NEW: Requests for Academic Consideration using the Self-Reported Absence Form

If you experience an unexpected illness or injury or an extenuating circumstance (48 hours or less) that is sufficiently severe to temporarily render you unable to meet academic requirements (e.g., attending lectures or labs, writing tests or midterm exams, completing and submitting assignments, participating in presentations) you should self-declare using the online Self-Reported Absence portal. This option should be used in situations where you expect to resume academic responsibilities within 48 hours or less.

Each student will be allowed a maximum of two self-reported absences between September and April and one self-reported absence between May and August. Self-reporting may not be used for final exams or assessments (e.g. midterm exams, tests, reports, presentations, or essays) worth more than 30% of any given course.

For full instructions about the Self-Reporting System refer to the Academic Calendar: http://westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=1&Command=showCategory&Keywords=report&SubHeadingID=32&SelectedCalendar=Live&ArchiveID=#SubHeading_322

A. GENERAL REGULATIONS & PROCEDURES (other than self-reported absences)

1. All first year students will report to the Undergraduate Services Office, SEB 2097, for all instances.

2. If you are an upper year student and you are missing a test/assignment/lab or examination that is worth LESS THAN 10% of your mark, you should report to your department office to request relief. If your course work is worth MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097.

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 (other than self-reported absences)

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. 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, you should report to your department office to request relief. If the test is worth MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request relief.

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

4. Discuss with the instructor if and when the test can be rescheduled. N.B. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.
C. **FINAL EXAMINATIONS (cannot be self-reported)**

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to 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 sign a "Recommendation for a Special Examination Form" available in the Undergraduate Services Office. 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 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 2019 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Self-Reporting Absences:
http://westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=1&Command=showCategory&Keywords=report&SubHeadingID=322&SelectedCalendar=Live&ArchiveID=SubHeading_322

Absences Due to Illness:
http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=Page_12

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/forms/smc.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”)  
Full courses and full-year half course (i.e. “E”, “Y” or no suffix)  
Second term half course (i.e. “B” or “G”)  

Drop Deadlines:  
First term half course (i.e. “A” or “F”)  
Full courses and full-year half courses (i.e. “E”, “Y” or no suffix)  
Second term half or second term full course (i.e. “B” or “G”)  

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: cbegrad@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: eccugrad@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

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