ECE 3390B: Hardware. Software. Co-Design.

Course Outline 2023-2024

Description: Consider the advances in Artificial Intelligence that have been made possible by Computer Engineers at NVIDIA, AMD, Intel, and TMSC. Against this backdrop, we will consider the co-design of Hardware/Software systems in the context of a counterposed initial question: "Is Software designed for Hardware, or is Hardware designed for Software?". From this standpoint, we will examine a number of case studies in which the overall design of a computer system will involve iterations of both Software Design and Hardware Design. These iterations expose the Hardware/Software interface in ways which are foundational to Computer Engineering and provide insights which are fundamental for Software Engineering, Mechatronics, and Electrical Engineering. In addition to case studies, the course will selectively review a variety of topics that span Computer Science and Computer Engineering, with emphasis on theoretical constructs from automata theory and formal language theory. While the course is designed to be as language-independent as possible, case studies will be developed as exercises, where high-level software will be implemented in C/C++ and hardware systems will be represented using VHDL, accompanied by semantically equivalent diagrams adopting UML 2.0 and digital circuit component diagrams.

Academic Calendar Copy: "Modern design techniques for classical and novel computing systems. Unified approach to hardware and software design. Partitioning of systems into hardware and software. Hardware/software interface design. Trade-offs in hardware and software partitioning".

Contact Hours: 3 lecture hours, 3 hours lab/tutorial exercises which can be done independently on the students' laptops in school or at home.   0.5 course.

Antirequisite: n/a

Prerequisites: ECE 2277a/b

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 50%, Engineering Design 50%.

Required Textbook: Access to materials on OWL course website.

Other Required References: none.

Recommended References: Parhami, B "Computer Architectures from Microprocessors to Supercomputers" Oxford University Press. Revised Edition

Other useful Reference Materials:

"Computer organization and design: the hardware/software interface" David A. Patterson & John L. Hennessy Morgan Kaufmann (Elsevier). Revised Edition

General Learning Objectives (CEAB Graduate Attributes)

Knowledge Base		Use of Engineering Tools	3/3	Impact on Society and the Environment	
Problem Analysis	3/3	Individual and Team Work	2/2	Ethics and Equity	
Investigation		Communication Skills		Economics and Project Management	
Design	3/3	Professionalism		Life-Long Learning	

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.

Course Topics and Specific Learning Outcomes	CEAB Graduate Attributes Indicators
1. Introduction to the Co-Design of Computer Systems, with consideration to both Hardware and Software Aspects. At the end of this section, students will be able to:	
a. Understand how the Design of Computer Systems requires consideration for both the Hardware and Software capacities and Structural and Behavioural constraints of a Computer System.	**ET1, PA1, D1**
b. Understand how the Design of Computer Systems will be formalized using diagrams and languages which will be expressed using entities and relations which will be combined using Node/Edge graphs, or formal languages using declarations, imperatives, and conjunctions.	**ET2, PA2, D2**
c. Understand and articulate the Foundational aspects of Computational Systems, as mapping abstract algorithms and data structures onto physical system implementations.	**ET2, PA2**
d. Understand and articulate how Computational Systems can be described using Behavioural and Structural representations.	**ET3, PA3**

e. Understand that there are a range of representational frameworks that can express the behavioural and structural aspects of Computer Systems (e.g. ANSI C, C++, VHDL, Verilog, LISP, JQuery, etc)	**ET3, PA3**
f. Understand how Computer and Software Engineering is conducted as a team-based Engineering Enterprise, emphasizing the principals of Engineering communication of formal system semantics, and including the commercialization of systems and optimization of systems from a cost-centric perspective.	**P2,ITW1, ITW2, ITW3**

2. Engineering of Software that is Designed according to Computer Hardware constraints

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

a. Understand and Apply how computer Software can be represented diagrammatically, where the semantics of the behaviour is represented within an hierarchical visual syntax.	**PA1, PA2, D1**
b. Understand and Apply how computer Software can be represented using formal languages, where the semantics of the behaviour is represented using text conforming to the syntax of various programming languages.	**PA2**
c. Design Software in accord with Case Studies provided in class and as assigned exercises, emphasizing the Engineering of Software that is Designed according to Computer Hardware constraints	**PA2, ITW2**

3. Engineering of Computer Hardware that is Designed according to Software constraints

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

a. Understand and Apply how Computer System Hardware can be represented diagrammatically, where the semantics of the structure is represented within an hierarchical visual syntax.	**D1, D2**
b. Understand and Apply how computer system Hardware can be represented using formal languages, where the semantics of their Architectural Structure is represented using text conforming to the syntax of various hardware description languages.	**PA2, D3**
c. Design Software in accord with Case Studies provided in class and as assigned exercises, emphasizing the Engineering of Computer Hardware that is Designed according to Software constraints.	**D3, D4**

4. Hardware/Software Co-Design as a unified approach to the Engineering of Computer Systems

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

d. Understand and appreciate, within a historical context, the success and failures of various landmark case studies in Hardware/Software Co-Design.	**KB1, ITW3**
e. Understand and be able to articulate the various approaches to	**D4, KB4, PA3**

evaluating the performance of Computer Systems.	
f. Understand and be able to design methodologies for testing and evaluating Computer System Performance within the context of the Hardware/Software trade-offs according to criterea of each.	**PA3**
g. Understand and appreciate the Analysis of Computer Systems within the marketplace, and how an Engineering Approach can provide a context for those systems.	**ITW3**

Evaluation

Course Component	Weight
Online Quizzes based on Lectures and Assignments	15 %
Online Participation in Lectures and Assignments	4 %
Midterm Examination based on Lectures / Assignments	31%
Final Examination based on Lectures / Assignments	50%

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

Homework Lab/Assignments: as assigned in class and noted on OWL

Quizzes: administered online using OWL

Participation: a Participation Mark will be assessed from a rank indexing of student interaction during online interactive sessions, based on zoom chat logs, discussions via voice and/or video zoom interaction, responding to questions or polls during the online lectures, participation in formative quizzes, and online attendance.

Midterm Test: as scheduled in class and noted using OWL

Final Examination: The final examination will be take place during the regular examination period, and administered online using OWL.

Late Submission Policy: The lab/assignments will have deadline date/times incorporated with each assignment, and the OWL dropbox system will timestamp the upload from each student. Late penalties will accrue at the daily rate of 5% of the weighted allocation of marks.

Assignment Submission Locker: Lab/Assignments will be submitted using the OWL dropbox.

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: A make-up evaluation will be scheduled as soon as possible after a missed evaluation. 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 decide whether to provide a make-up test or allow 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.

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 permitted during examinations.
Use of Personal Response Devices ("Clickers"): will not be required for this course.

Use of Recordings: **All of the remote learning sessions for this course may be recorded.** The data captured during these recordings may include your image, voice recordings, chat logs and personal identifiers (name displayed on the screen). The recordings will be used for educational purposes related to this course, including evaluations. The recordings may be disclosed to other individuals under special circumstances. Please contact the instructor if you have any concerns related to session recordings.

Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor.

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.