ENGG*6530 Reconfigurable Computing Systems
Winter 2022

UNIVERSITY of GUELPH

School of Engineering

(Revision 3: September, 04, 2019)

INSTRUCTIONAL SUPPORT

Instructor

Instructor:	Shawki Areibi, Ph.D., P.Eng.
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Courses Web Page:	https://sareibi.uoguelph.ca/undergraduate-courses/
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Office hours:	Fridays: 3:00 - 4:00 PM

Lab Instructor/Coordinator

Instructor:	Haleh Vahedi
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LEARNING RESOURCES

Course Website

Course material, news, announcements, and grades will be regularly posted to the ENGG*6530 Course Webpage site. You are responsible for checking the site regularly.

Required Resources

1. Edited by S. Hauck and A. Dehon *Reconfigurable Computing: The Theory and Practice of FPGA-Based Computing*, **Publisher: Morgan Kaufmann**, 2008, ISBN 978-0-12-370522.

Recommended Resources

1. "Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications", by C. Bobda Springer, 2008, ISBN 978-1-4020-6088-5.

2. "VHDL for Engineers", by K. Short, 2nd Edition, Prentice Hall, 2008.
3. "The Designer's Guide to VHDL", by Peter Ashenden, Morgan Kaufmann, 2002, ISBN 1-55860-674-2.

Additional Resources

1. Lecture Information: All the lecture notes are posted on the web page (week #1-#6).
2. Project Information: The handouts for the projects are within the project section. All types of resources regarding tutorials, links to web pages can be found in this section.
3. Assignments: Download the assignments according to the schedule given in this handout. All the solutions will be posted as indicated.
4. Miscellaneous Information: Other information related to Reconfigurable Computing are also posted on the web page.

Communication & Email Policy

Please use lectures and lab help sessions as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. It is your responsibility to check the course website regularly. As per university regulations, all students are required to check their "uoguelph.ca" e-mail account regularly: e-mail is the official route of communication between the University and its student.

ASSESSMENT

Dates and Distribution

1. Labs/Assignments: 30%
   See Section 5 for due dates
2. Project: 25%
   Report Due Date: Week 12 2022
3. Paper Review: 10%
   Presentation: Week 11, 2022
4. Final Exam: 35%
   April 2022

Course Grading Policies

Missed Assessments: When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course in writing, with your name, id#, and e-mail contact. See the graduate calendar for information on regulations and procedures for Academic Consideration: https://www.uoguelph.ca/registrar/calendars/graduate/2019-2020/index.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Consideration of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Drop Date: The last date to drop one-semester courses, without academic penalty, is 40th day of classes. Two-semester courses must be dropped by the last day of the add period in the second semester. Refer to the Graduate Calendar for the schedule of dates:
http://www.uoguelph.ca/registrar/calendars/graduate/current/sched/sched-dates-w11.shtml

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AIMS, OBJECTIVES & GRADUATE ATTRIBUTES

Calendar Description

This course serves as a graduate introduction into reconfigurable computing systems. It introduces students to the analysis, synthesis and design of embedded systems and implementing them using Field Programmable Gate Arrays (FPGAs). Topics include: Programmable Logic devices, Hardware Description Languages, Computer Aided Design Flow, Hardware Accelerators, Hardware/Software Co-design techniques, Run Time Reconfiguration, High Level Synthesis.
Prerequisite(s): Digital Design (ENGG*2410) or equivalent

Course Aims

Reconfigurable Computing Systems (RCS) refers to a new class of computer architecture which take advantage of application level-parallelism. This course deals mainly with digital systems implemented on Field Programmable Gate Arrays (FPGA). In this course, we investigate the state-of-the-art in reconfigurable computing and the main factors driving it. Initially, we review the basic concepts of programmable logic in general and FPGAs in particular. Design entry based on Hardware Descriptive Languages and High Level Languages will also be covered. Specific reconfigurable computing systems (i.e architectures) will be examined with emphasis on limitations and future research opportunities.

Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability to:

1. Understand the basic concepts of Reconfigurable Computing both from a hardware/software perspective.
2. Learn all details of digital hardware, its specification, analysis, design and implementation.
3. Get acquainted with both low level hardware description languages (HDL) and state of the art high level languages such as Handel-C and Auto-ESL.
4. Use different analysis and verification tools, implementation and synthesis methodologies and testability techniques that will enable them to design high performance and efficient digital systems.
5. Implement a complete digital system on FPGAs using state-of-the art CAD tools.
6. Learn the basic flow of Electronic Design Automation (EDA) from design entry to implementation for FPGAs.

Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Course Web Page but these are not intended to be stand-alone course notes. During lectures, the instructor will expand and explain the content

of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and project.

Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and tutorials. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

Relationships with other Courses

ENGG*6530 and its lab will teach you plenty about digital hardware, its specification, design and implementation. More importantly however, is that it prepares you for lower level hardware description languages (HDL) and their use in computer architecture.

The course prerequisite (ENGG*2410) is **essential** for the following reasons:
ENGG*2410, Digital Design:
This course is an introductory course in digital logic design, which is a basic course in most electrical and computer engineering programs. ENGG*2410 introduces students to design, synthesis and realization of combinational circuits. Design, synthesis and realization of sequential circuits. VHDL: structural modeling, data flow modeling, synchronous & asynchronous behavior descriptions, algorithmic modeling. Designing with PLDs. The main goals of the course are (1) to teach students the fundamental concepts in classical manual digital design and (2) to illustrate clearly the way in which digital circuits are designed today, using CAD tools.

The course (ENGG*3380) is **recommended** for the following reasons:
ENGG*3380, Computer Organization:
This course contains a detailed examination of modern computer organization and techniques for microprocessor architecture design. Topics include - CPU design; instruction set design, addressing modes, operands; data flow design: internal bus structure, data flow signals, registers; control sequence design: hardwired control, decoding, micro-programming; architecture classes: CISC, RISC, and DSP; Memory organization; performance.

TEACHING AND LEARNING ACTIVITIES

Timetable

Lectures:

Lecture	Time	Location	Instructor
Tuesday	11:30 AM - 12:50 PM	RICH 2531 or Online (Webex)	S. Areibi
Thursday	11:30 AM - 12:50 PM	RICH 2531 or Online (Webex)	S. Areibi

Lecture Schedule

Lectures	Lecture Topics	References	Learning Objectives
1-2	Introduction to Reconfigurable Computing	Chapter 1,2,3	1
3-4	Digital Design: Arithmetic	Mano	1
5-6	Programmable Logic Devices (FPGAs, CPLDs)	Chapter 2,3	1,2,3
7-9	Hardware Descriptive Languages (VHDL)	Chapter 5,6	5,6
10-12	Hardware Descriptive Languages (VHDL)	Chapter 5,6	5,6
13-15	CAD for FPGAs (Placement, Routing, Synthesis)	Chapter 13,14	2,3,4,5,6
16-18	Hardware/Software Co-Design	Chapter 26	2,3,5,6
19-21	Electronic System Level (ESL, Handel-C)	Chapter 7	3,4,5,6
22-24	Dynamic Run-time Reconfiguration	Chapter 4	2,3,4,5,6
25-27	Application Specific Instruction Processors	Chapter 10	2,3,4,5
28-30	Operating Systems for RTR	Chapter 11	4,5
31-33	*Paper Review*	Papers	4,5,6
34-36	*Advanced Topics*	Chapter 31	4,5,6

Assignments

There will be 7 assignments throughout the term. **Solve all problems** and hand it in during the lecture.

Assignment #	Handed In	Due Date	Topic
Assign #1	(Week #1)	(Week #3)	Design of Arithmetic Circuits
Assign #2	(Week #3)	(Week #4)	Design of a Datapath
Assign #3	(Week #4)	(Week #5)	Design of SIMD/Control Unit
Assign #4	(Week #5)	(Week #7)	Design of Custom IP (H/S Co-Design)
Assign #5	(Week #7)	(Week #9)	Xilinx High Level Synthesis (HLS)

Paper Review

Besides the assignments, each student is assigned a journal article to read. The student must prepare a brief (about 30-45 minutes) oral description of the article, its objectives, methods, results and contributions to present to the class. A two page summary (detailed) giving the citation and the material in the oral presentation must be written and a copy is distributed to each class member. The articles are selected so that they pertain to current or very recent classroom material. **Several topics and related literature are found on the course web-page**. Here are some general points to consider when reading about a particular study:

- What is the general purpose of the article, who it is intended for, and why is the topic important.
- What are the main results.
- Indicate the technique used and the experimental methodology followed. Was the analysis sufficient?
- What do you think is the main contribution of the article? How is work unique? Who might benefit from the results? Practitioners, researchers, managers, etc?
- What are the weaknesses and strengths of the work? How might it have been improved? What are your recommendations for future work in this area.

The following are some conferences and journals that you can get articles from:

- ACM/IEEE Conference on Field Programmable Gate Arrays.

- IEEE Transactions on Computers.
- IEEE Conference on Systems Man, and Cybernetics.
- IEEE Transaction on Computer Aided Design.
- International Conference on Computer Aided Design.
- Design Automation Conference.

Research Project

Each of you will select a topic related to FPGA/RCS design. You should conduct an in-depth study covering the problem to be solved and its origins, developments, and current status. This will involve extensive research; your findings should be documented in a report with the basic references cited. Background reading should include several articles. In writing your report you should think about what you have read, and provide your personal opinions about the presentation and usefulness of the work. **Sample projects could be found on the course web-page**.

Other Important Dates

1. **First Class**: Tuesday January 11th 2022,
2. **Reading Week**: February 21st - February 25th,
3. **Drop Date:** Friday, March 11th.
4. **Last Class**: Thursday, April 7th, 2022.
5. **Exams Commence**: Monday, April 11th, 2022.

LAB SAFETY

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

ACADEMIC MISCONDUCT

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community - faculty, staff, and students - to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offence from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Resources

The Academic Misconduct Policy is detailed in the Graduate Calendar:
https://www.uoguelph.ca/registrar/calendars/graduate

A tutorial on Academic Misconduct produced by the Learning Commons can be found at:
http://www.academicintegrity.uoguelph.ca/

Please also review the section on Academic Misconduct in the Program Guide:
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml.

The School of Engineering has adopted a Code of Ethics that can be found at:
http://www.uoguelph.ca/engineering/undergrad-counselling-ethics

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ACCESSIBILITY

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability for a short-term disability should contact the Centre for Students with Disabilities as soon as possible

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RECORDING OF MATERIALS

Presentations which are made in relation to course work-including lectures-cannot be recorded in any electronic media without the permission of the presenter, whether the instructor, a classmate or guest lecturer.

RESOURCES

The Graduate Calendar is the source of information about the University of Guelph's procedures, policies and regulations which apply to graduate programs: http://www.uoguelph.ca/registrar/calendars/graduate/current