Reconfigurable Computing

EEL5721/4720
Class Periods: MFW, Period 3 (9:35 to 10:25)
Location: NEB 100
Academic Term: Fall 2018

Instructor:
Greg Stitt
gstitt@ufl.edu
352-392-5348
Office Hours: M Period 2, W Period 2, BEN 318 (subject to change)

Teaching Assistants:
Please contact through the Canvas website
- Seyed Hashemi, hashemi@ufl.edu
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Course Description

Fundamental concepts at advanced undergraduate level (EEL4720) and introductory graduate level (EEL5721) in reconfigurable computing based upon advanced technologies in field-programmable logic devices. Topics include general concepts, device architectures, design tools, metrics and kernels, system architectures, and application case studies (3 credit hours)

Course Pre-Requisites / Co-Requisites

EEL4712C or EEL5764 or consent of instructor:

Fundamentals of digital design including design technologies, design methodology and techniques, and design environments and tools; fundamentals of computer organization and architecture, including microprocessor datapath and control structures, data formats, instruction-set principles, pipelining, instruction-level parallelism, memory hierarchy, and interconnects and interfacing.

Course Objectives

Students will gain fundamental knowledge and understanding of principles and practice in reconfigurable architecture and computing through class lectures and discussions, reading assignments, homework and lab experiments, and a major research project.

Materials and Supply Fees: n/a

Relation to Program Outcomes (ABET):

Outcome	Coverage
a. Apply knowledge	Medium
b1. Conduct experiments	
b2. Statistical design of experiments	
c. Design	Medium
d. Function on teams	
e. Solve problems	Medium
f. Professional and ethical responsibility	
g. Communicate	
h1. Economic impact	
h2. Global, societal, and environmental impact	
i. Lifelong learning	

j. Contemporary issues	
k. Techniques, skills, and tools for degree program	Medium

Required Textbooks and Software
- No required book
- Reading material consists of research papers
- Professor will provide slides
- Software: Xilinx Vivado, ssh client

Recommended Materials
- C. Maxfield, *The Design Warrior's Guide to FPGAs*, Newnes, 2004, ISBN: 978-0750676045.
- F. Vahid and R. Lysecky. VHDL for Digital Design, Wiley, 2007, ISBN: 978-0470052631.
- M. Gokhale and P. Graham, *Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays*, Springer, 2005, ISBN: 978-0-387-26105-8.
- C. Bobda, *Introduction to Reconfigurable Computing: Architectures, Algorithms and Applications*, Springer, 2007, ISBN: 978-1402060885.
- P. Lysaght and W. Rosenstiel (eds.), *New Algorithms, Architectures and Applications for Reconfigurable Computing*, Springer, 2005, ISBN: 978-1402031274.
- D. Pellerin and S. Thibault, *Practical FPGA Programming in C*, Prentice-Hall, 2005, ISBN: 978-0131543188.
- W. Wolf, *FPGA-based System Design*, Prentice-Hall, 2004, ISBN: 0-13-142461-0.
- R. Cofer and B. Harding, *Rapid System Prototyping with FPGAs: Accelerating the Design Process*, Newnes, 2005, ISBN: 978-0750678667.
- N. Voros and K. Masselos (eds.), *System-Level Design of Reconfigurable Systems-on-Chip*, Springer, 2005, ISBN: 978-0387261034.
- G. De Micheli, *Synthesis and Optimization of Digital Circuits*, McGraw-Hill, 1994, ISBN: 978-0070163331r

Course Schedule
  I. General overview (< 1 week)
  - Goals and motivations
  - History, state of the art, future trends
  - Basic concepts and related fields of study
  - Performance, power, and other metrics
  - Algorithm analysis and speedup projections

  II. VHDL Tutorial (~1 week)

  III. RC Architectures (~1 week)
  - Device characteristics
  - Fine-grained architectures
  - Coarse-grained architectures

  IV. FPGA Physical Design Tools (~1 week)
  - Technology mapping
  - Placement & routing

  V. Register Transfer (RT)/Logic Synthesis (1-2 weeks)
  - Controller/Datapath synthesis
  - Logic minimization

  VI. RC Application Design (1-2 weeks)

- ▪ Parallelism
- ▪ Systolic arrays
- ▪ Pipelining
- ▪ Optimizations
- ▪ Bottlenecks

VII. High-level Design (~3 weeks)
- ▪ High-level synthesis
- ▪ High-level languages
- ▪ Design tools

VIII. Hybrid architectures (~1 week)
- ▪ Hybrid architectures
- ▪ Communication
- ▪ Hw/sw partitioning
- ▪ Soft-core microprocessors

IX. System architectures (2-3 weeks)
- ▪ System design strategies
- ▪ System services
- ▪ Small-scale architectures
- ▪ HPC architectures
- ▪ HPEC architectures
- ▪ System synthesis
- ▪ Architectural design space explorations

X. Case Studies (~1 week)
- ▪ Signal and image processing
- ▪ Bioinformatics
- ▪ Security

XI. Special Topics (~2 weeks)
- ▪ Partial Reconfiguration
- ▪ Numerical Analysis
- ▪ Performance Analysis/Prediction
- ▪ Fault Tolerance

Lab Experiments: A series of laboratory experiments will be assigned in synchronization with the topics covered in class lecture. These experiments will be undertaken by small teams of students in an open-lab environment in the first half of the semester. Students enrolled in the graduate section of this course may be assigned extra tasks for each lab. Special arrangements will be made for EDGE students.

Project: Students will form small teams and undertake a major project (on a topic subject to instructor approval) exploring fundamental issues in reconfigurable computer architectures, systems, and applications. Special arrangements will be made for EDGE students. This project will span the second half of the semester and provide students the opportunity to more deeply explore fundamental issues in RC. Students enrolled in the graduate section of this course will undertake a significantly broader and deeper topic or role than those in the undergraduate section. The culmination of each project for a graduate student will be a clear and concise technical report suitable for publication discussing project concepts, development, experiments, results, and analyses. The most important outcome of each project and report will be the research results that are achieved, analyses rendered, and conclusions drawn with demonstrable insight.

Equipment: All assignments will use FPGA boards that can be connected to remotely over SSH. Students do not need to purchase any equipment.

Attendance Policy, Class Expectations, and Make-Up Policy
Attendance optional, but strongly recommended. Conflicts with due dates or exam dates should be brought to the professor's attention as early as possible to allow for special arrangements to be made. Excused absences are consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation.

Evaluation of Grades

EEL4720:
- Midterm1 (Monday, October 8th*, 50 minutes): 25%
- Midterm2 (Wednesday, December 5th*, 50 minutes): 25%
- Labs/Homework: 25%
- Project: 25% (this may vary based on difficulty of chosen final project)

EEL5721:
- Midterm1 (Monday, October 8th*, 50 minutes): 25%
- Midterm2 (Wednesday, December 5th*, 50 minutes): 25%
- Labs/Homework: 25%
- Project: 25%(this may vary based on difficulty of chosen final project)

EDGE Students can take Midterm 1 from October 8-10 and Midterm 2 from December 3-5

Grading Policy
- A: 90
- A-: 87
- B+: 83
- B: 80
- Etc.

*Final grade to be determined by curved average of exams, assignments, and project.

For 4720: A C- will not be a qualifying grade for critical tracking courses. In order to graduate, students must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: a C- average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement. For more information on grades and grading policies, please visit: https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx.

For 5721: Undergraduate students, in order to graduate, must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: a C- average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement. Graduate students, in order to graduate, must have an overall GPA of 3.0 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement. For more information on grades and grading policies, please visit: https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx.

Make-up Exam Policy: Missed exams cannot be made up, except in case of documented medical emergency. EDGE students will have a 3-day window to take the test.

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at https://evaluations.ufl.edu/evals. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results/.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html

Campus Resources:

Health and Wellness

> **U Matter, We Care:**
> If you or a friend is in distress, please contact umatter@ufl.edu or 352 392-1575 so that a team member can reach out to the student.
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> **Counseling and Wellness Center:** http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.
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> **Sexual Assault Recovery Services (SARS)**
> Student Health Care Center, 392-1161.
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> **University Police Department** at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints*: http://www.distance.ufl.edu/student-complaint-process.