

# Reconfigurable Computing

EEL5721/4720

**Class Periods:** MFW, Period 2 (8:30 to 9:20)

**Location:** NEB 100

**Academic Term:** Fall 2019

## **Instructor:**

Greg Stitt

[gstitt@ufl.edu](mailto:gstitt@ufl.edu)

352-392-5348

Office Hours: M Period 3, W Period 3, BEN 315 (subject to change)

## **Teaching Assistants:**

Please contact through the Canvas website

- Samantha Soto, [ssoto65@ufl.edu](mailto:ssoto65@ufl.edu)

## **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*
1. An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.	Medium
2. An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs.	Medium
3. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	
4. An ability to communicate effectively with a range of audiences	
5. An ability to recognize ethical and professional responsibilities in	

engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	
6. An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately.	Medium
7. An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty	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 graduate/undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>, <http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance>) and require appropriate documentation.

### ***Evaluation of Grades***

#### **EEL4720:**

- Midterm1 (Monday, October 7<sup>th</sup>\*, 50 minutes): 25%
- Midterm2 (Wednesday, December 4<sup>th</sup>\*, 50 minutes): 25%
- Labs/Homework: 25%
- Project: 25% (this may vary based on difficulty of chosen final project)

#### **EEL5721:**

- Midterm1 (Monday, October 7<sup>th</sup>\*, 50 minutes): 25%
- Midterm2 (Wednesday, December 4<sup>th</sup>\*, 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 7-9 and Midterm 2 from December 2-4**

### ***Grading Policy***

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

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

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

### ***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 professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-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.

### **Commitment to a Safe and Inclusive Learning Environment**

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, [rbielling@eng.ufl.edu](mailto:rbielling@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

### **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: <https://registrar.ufl.edu/ferpa.html>

### **Campus Resources:**

#### Health and Wellness

##### **U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one

another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**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.

**Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

**Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto: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](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

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