# Reconfigurable Computing

EEL 4720   Section 12913
***Class Periods:***   MWF, Period 2 (8:30am – 9:20am)
***Location:***   NEB 0100
***Academic Term:***   Fall 2023

***Instructor:***
Greg Stitt
gstitt@ufl.edu
352-392-5348
Office Hours:   M Period 3, T Period 2, on Zoom and in Benton 315 (subject to change)

***Teaching Assistant/Peer Mentor/Supervised Teaching Student:***
Please contact through the Canvas website
- Jared Herbert (TA), office hours: T,W Period 5 MAE-B 328
- Nashmin Alam (Supervised Teacher), office hours: R,F 3-4pm MAEB 226

***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***
$57.99 course fee

***Relation to Program Outcomes (ABET):***

| Outcome | Coverage* |
|---|---|
| 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics | High |
| 2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors | |
| 3. An ability to communicate effectively with a range of audiences | Low |
| 4. 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 | |
| 5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives | Medium |
| 6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions | High |
| 7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies | 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
n/a

## 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

### *Attendance Policy, Class Expectations, and Make-Up Policy*

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:
https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

### *Evaluation of Grades*

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.

| Assignment | Total Points | Percentage of Final Grade |
|---|---|---|
| Labs (6 total) | 100 each | 25% |

| | | |
|---|---|---|
| Midterms (2 total) | 100 each | 50% (25% each) |
| Project | 100 | 25% |
| | | 100% |

### *Grading Policy*

| Percent | Grade | Grade Points |
|---|---|---|
| 90.0 - 100.0 | A | 4.00 |
| 87.0 - 89.9 | A- | 3.67 |
| 84.0 - 86.9 | B+ | 3.33 |
| 81.0 – 83.9 | B | 3.00 |
| 78.0 - 80.9 | B- | 2.67 |
| 75.0 - 79.9 | C+ | 2.33 |
| 72.0 – 74.9 | C | 2.00 |
| 69.0 - 71.9 | C- | 1.67 |
| 66.0 - 68.9 | D+ | 1.33 |
| 63.0 - 65.9 | D | 1.00 |
| 60.0 - 62.9 | D- | 0.67 |
| 0 - 59.9 | E | 0.00 |

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 who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, 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/.

### **In-Class Recording**
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

### 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/process/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 varied perspectives and lived experiences within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

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
• HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, 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 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:** https://counseling.ufl.edu, 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

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

**Career Connections Center**, Reitz Union, 392-1601.  Career assistance and counseling; https://career.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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

**On-Line Students Complaints***:* https://distance.ufl.edu/getting-help/; *https://distance.ufl.edu/state-authorization-status/#student-complaint.*