

**Parallel Computer Architecture**  
EEL 6763 All sections  
**Class Periods:** MWF 4<sup>th</sup> period, 10:40 – 11:30 am  
**Academic Term:** Fall 2020

**Instructor:**

Dr. Herman Lam  
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Benton 313  
Office Hours: TBD

**Course (Catalog) Description**

Advanced architecture emphasizing design and quantitative analysis of parallel architecture and systems, including theory, hardware technologies, parallel and scalable architectures, and software constructs.

**Course Pre-Requisites / Co-Requisites**

EEL5764 Computer Architecture; or consent of instructor

**Course Objectives**

The main objective of this course is to study the fundamental and newly developing hardware and software topics in parallel computer architecture (PCA), including concepts, models, methods, metrics, systems, and applications. PCA has become one of the most challenging and important areas of ECE, and it is now a dominant theme throughout computer architecture, systems, and programming, from low-power embedded systems to high-end supercomputers, and featuring various forms of fixed-logic (e.g., CPU, GPU, DSP), reconfigurable-logic (e.g., FPGA), and hybrid (e.g., CPU + GPU, CPU + FPGA, CPU + GPU + FPGA + other emerging accelerators) processing devices.

Students will gain fundamental knowledge and understanding of principles and practice in parallel computer architecture and computing, emphasizing both hardware and software challenges and their interactions. Additionally, students will be exposed to fundamental co-design techniques in order to optimize parallelism and gain practical insight into the parallelization process, as well as exposure to state-of-the-art and emerging research challenges in this field. Using HiPerGator, the University of Florida supercomputer, extensive on-hand experience is provided through labs and a class project.

**Required Materials**

- Textbook – none
- Research papers to be assigned
- Class notes
- Vendor documentation

**Recommended Materials**

- A. Grama, A. Gupta, G. Karypis, and V. Kumar, Introduction to Parallel Computing, 2nd Edition, Pearson: Addison-Wesley, 2003. An errata list is available by John Kirk.
- D. Culler and J. Singh, Parallel Computer Architecture: A Hardware/Software Approach, Morgan Kaufmann, 2013.
- P. Pacheco, An Introduction to Parallel Programming, Morgan Kaufmann, 2011.
- B. Gaster, L. Howes, D. Kaeli, P. Mistry, and D. Schaa, Heterogeneous Computing with OpenCL, Morgan Kaufmann, 2011.

**System/software:**

- **HiPerGator**, the University of Florida supercomputer provided by UF Research Computing (UFRC), will be used to implement the labs and projects. The programming languages used will be C/C++, combined with parallel programming languages such as MPI, OpenMP, and CUDA.

## ***Course Topics:***

- General Overview
  - Motivation: why parallel computing
  - Fundamentals of parallel computing
    - PCA components & systems
    - PCA architectures: Flynn's taxonomy, based on memory organization
    - Parallel programming models
- PCA Architectures
  - Classical taxonomy
  - Memory architectures: shared memory, distributed memory, hybrid
  - Communication architectures: interconnect topology, routing
- Parallel program models and languages
  - Message passing: e.g., MPI
  - Shared memory: e.g., OpenMP
  - Other programming models (e.g., hybrid, PGAS) and languages (CUDA, OpenCL)
- Parallel application design and implementation
  - Parallel algorithm design: decomposition techniques, mapping and scheduling, synchronization
  - Optimization strategies: load-balancing, scalability, locality/communication, memory optimization
- Performance evaluation
  - Analytical modeling, benchmarking & performance measurement
  - Performance metrics: speedup, efficiency, scalability
  - Performance tools: gprof, vtune, mpip, etc.
- Case studies and special topics
  - Case study HPC systems: e.g., Titan, Summit
  - Case-study HPC research projects: e.g., CMT-nek, BE-SST
  - Emerging Heterogeneous HPC systems: Combination of CPUs, GPUs, other accelerators (e.g., FPGAs), emerging devices (e.g., emerging memory devices)

***Lab Experiments:*** A series of laboratory experiments (spanning the first half of the semester) will be assigned in synchronization with the topics covered in class lectures.

- MPI programming assignment
- OpenMP programming assignment
- CUDA programming assignment
- Profiler tools for performance analysis

***Research Project:*** A research project will be assigned to explore fundamental issues in parallel computer architectures, systems, and applications. This project will span more than half of the semester and provide students the opportunity to explore fundamental issues more deeply in PCA. Students will form small teams to propose and then conduct an experimental research project on a topic in PCA of their choosing (subject to professor approval). Each project will involve elements of both hardware and software in parallel computing. The culmination of each project will be a clear and concise technical report suitable for potential publication discussing project concepts, development, experiments, results, and analyses. The most important outcome of each project will be the research results that are achieved, analyses rendered, and conclusions drawn with demonstrable insight.

### ***Online Course Recording***

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

### ***F2F Course Policy in Response to COVID-19***

We will have face-to-face instructional sessions to accomplish the student learning objectives of this course. In response to COVID-19, the following policies and requirements are in place to maintain your learning environment and to enhance the safety of our in-classroom interactions.

- You are required to wear approved face coverings at all times during class and within buildings. Following and enforcing these policies and requirements are all of our responsibility. Failure to do so will lead to a report to the Office of Student Conduct and Conflict Resolution.
- This course has been assigned a physical classroom with enough capacity to maintain physical distancing (6 feet between individuals) requirements. Please utilize designated seats and maintain appropriate spacing between students. Please do not move desks or stations.
- Sanitizing supplies are available in the classroom if you wish to wipe down your desks prior to sitting down and at the end of the class.
- Follow your instructor's guidance on how to enter and exit the classroom. Practice physical distancing to the extent possible when entering and exiting the classroom.
- If you are experiencing COVID-19 symptoms (Click here for guidance from the CDC on symptoms of coronavirus), please use the UF Health screening system and follow the instructions on whether you are able to attend class. Click here for UF Health guidance on what to do if you have been exposed to or are experiencing Covid-19 symptoms.
- Course materials will be provided to you with an excused absence, and you will be given a reasonable amount of time to make up work. Find more information in the university attendance policies.

### ***Attendance Policy, Class Expectations, Makeup Policy***

This class will be presented online using Zoom and requires access to a working webcam and stable internet connection. I prefer that students keep their camera on during the class so that I can see you as I would during normal face-to-face classes. Studies show that if we can see each other's faces then we will have more engagement, more student success, and more faculty success. However, this is not a requirement. I understand if on certain days you can't have your camera on due to internet bandwidth limitations, other family members, health issues, or any other reasons.

There are no scheduled makeup exams. Makeup exams are handled case-by-case, mainly for documented illness and emergencies.

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

<b>Assignment</b>	<b>Total Points</b>	<b>Percentage of Final Grade</b>
Midterm exam	100	25%
Final Exam	100	30%
Labs	100 each	Cumulatively 15%
Project	100	30%

## **Grading Policy**

The following is the standard grading scale and serves as the basic guideline. Final grade assignments will be adjusted based on class performance (e.g., class averages on different class deliverables).

<b>Percent</b>	<b>Grade</b>	<b>Grade Points</b>
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:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

## **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/>.

## **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://care.dso.ufl.edu>.

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