Course Syllabus

ECE 8930: Extreme-Scale Parallel Programming

Term: Fall 2024

August

- Aug 23, Wed Classes begin
- Aug 29, Tue Last day to register or add a class or declare Audit

September

- Sep 6, Wed Last day to drop a class or withdraw from the University without a W grade

November

- Nov 1, Wed Last day to drop a class or withdraw from the University without final grades

Class Meeting Time and Place:

Sirrine 204 TR 9:30 AM – 10:45 PM

Time to Wait:

Class is cancelled if the instructor is more than 15 minutes late to class and there is no email message or Canvas post explaining otherwise.

Information on Modality:

In-person

Instructor Name:

Jon C. Calhoun

Instructor Email:

jonccal@clemson.edu

To receive a response, emails must be sent from your Clemson University email address to the professor's @clemson.edu email and must include the course number in the subject line. The professor will respond within 24-hours during weekdays unless on travel.

University Office Phone:

864-656-2646

Office Address/Office Number:

Riggs 209

Office Hours:

Thursday – 11:00 AM – 12:00 PM

Course Description

Parallel programming is essential to large-scale scientific simulations and distribution machine learning. As applications are given more computational resources users expect performance to scale proportionally, but often does not! This course investigates the bottlenecks to performance from the perspective of a sequential process to distributed memory applications using thousands of processes. This course covers a range of factors that impact performance and scalability: performance modeling, caching, pipelining, SIMD, shared memory programing, distributed memory programming, collective communications, and parallel I/O.

Prerequisites

ECE 4730 is recommended, but not required.

Learning Objectives / Outcomes

- Students will be able to describe what HPC is and its applications
- Students will be able to state and explain what bottlenecks an application's performance
- Students will explore metrics to evaluate performance and scalability of applications
- Students will develop performance models to create performance expectations and benchmark code/systems
- Students will be able to compare and contrast shared memory and distributed memory programming models
- Students will leverage course topics to accelerate parallel applications and quantify both speedup and scalability

Required Materials

Textbook: None. Internet connected laptop with a webcam, microphone, and speakers/headphones.

Recommended Materials

TBD

How to Be Successful in this Course

- Be prepared for all classes
- Read required material before class
- Actively contribute to the learning activities in class
- Abide by the University Academic Integrity Policy
- Start homework and projects early

Topical Outline

What is HPC? 1 week

Benchmarking, performance metrics, and performance modeling 2 weeks

Single Threaded performance 4 weeks

- Caching
- Instruction Level Parallelism and Pipelining
- Vectorization

Shared Memory Programming 2 weeks

- OpenMP
- Non-uniform Memory Access (NUMA) and Speedup

Distributed Memory 7 weeks

- MPI Basics
- Point-to-Point Communication
- Collective Communication
- Performance Models
- Speedup, Efficiency, and Iso-efficiency
- Parallel I/O
- One-sided communication
- Asynchronous Execution

A per class outline is available on the course's Canvas page.

Major Assessment/Grading Activities

Homework and Programming Assignments	30%
Class Participation:	10%
Project (Team based):	60%

See the lecture slides and Canvas assignments for more details about each category.

Grading System

Letter	Points/Percentages
A	[90%, 100%]
B	[80%, 90%)
C	[70%, 80%)
D	[60%, 70%)
F	[0%, 60%)

Grading Policies

Late Work

Late assignments will have 1 letter grade deducted for each day that they are late. Examples of excused absences include a death in the immediate family or personal conditions requiring hospitalization or emergency treatment. Personal illnesses such as colds, general fatigue, or general sickness are not typically excused. If you are unsure if your situation will be excused, contact the professor in a professional manner prior to or as soon as possible after the missed assignment.

Absences

Attendance is mandatory; however, if you do need to miss class:

Notification of Absence

The **Notification of Absence module in Canvas** allows students to quickly notify instructors (via an email) of an absence from class and provides for the following categories: court attendance, death of immediate family member, illness, illness of family member, injury, military duty, religious observance, scheduled surgery, university function, unscheduled hospitalization, other anticipated absence, or other unanticipated absence.

The notification form requires a brief explanation, dates, and times. Based on the dates and times indicated, instructors are automatically selected, but students may decide which instructors will receive the notification. This does not serve as an “excuse” from class. It is a

request for an excused absence and students are encouraged to discuss the absence with instructors, as the instructor is the only person who can excuse an absence. If students are unable to report the absence by computer, they may reach the Office of Advocacy and Success. Students with excessive absences who need academic or medical assistance can also contact the Office of Advocacy and Success.

Inclement Weather or Emergency

Any missed assignment due to inclement weather or emergency is due the next day the university is operational unless there is a Canvas announcement.

Standard Academic Policies

Academic Integrity

As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form.

All infractions of academic dishonesty by undergraduates must be reported to Undergraduate Studies for resolution through that office. In cases of plagiarism instructors may use the Plagiarism Resolution Form.

Additionally, for undergraduate classes:

Plagiarism, which includes the intentional or unintentional copying of language, structure, or ideas of another and attributing the work to one's own efforts. Graded works generated by artificial intelligence or ghostwritten (either paid or free) are expressly forbidden.

See the Undergraduate Academic Integrity Policy website for additional information and the current catalogue for the policy.

For graduate students, see the current Graduate School Handbook for all policies and procedures.

Accessibility

Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities,

course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to this class should let the instructor know and are encouraged to request accommodations through SAS (Student Accessibility Services) as soon as possible. To request accommodations through SAS, please see this link: (https://www.clemson.edu/academics/studentaccess/register.html). You can also reach out to SAS with questions by calling 864-656-6848, visiting SAS at the ASC Suite 239, or stopping by the office as a drop-in appointment.

The Clemson University Title IX Statement Regarding Non-Discrimination

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This Title IX policy is located on the Access and Equity website. Ms. Alesia Smith is the Clemson University Title IX Coordinator, and the Assistant Vice President of Equity Compliance. Her office is located at 223 Brackett Hall, 864-656-3181 and her email address is alesias@clemson.edu. Remember, email is not a fully secured method of communication and should not be used to discuss Title IX issues.

Clemson University aspires to create a diverse community that welcomes people of different races, cultures, ages, genders, sexual orientation, religions, socioeconomic levels, political perspectives, abilities, opinions, values and experiences.

Emergency Preparation

Emergency procedures have been posted in all buildings and on all elevators. Students should be reminded to review these procedures for their own safety. All students and employees should be familiar with guidelines from Clemson University Public Safety.

Clemson University is committed to providing a safe campus environment for students, faculty, staff, and visitors. As members of the community, we encourage you to take the following actions to be better prepared in case of an emergency:

1. Familiarize yourself with all possible exits, safer locations, and other key information on the emergency evacuation maps in this building, and those that you visit regularly.
2. Make a plan for how you would Run, Hide, and Fight in case of an active threat in this building, and those that you visit regularly. For example:
    a. Run – what are all the possible exits in this building, and the routes to them?

   b. Hide – what are the potential hiding locations in this room and building that are out of sight of doors and windows, how do you lock the door(s), how would you barricade the door(s) and windows, where do you turn off the lights?
   c. Fight – What tools are available in this room and building, should you have to fight?
3. Ensure you are signed up for emergency alerts. Alerts are only sent when there is a potential threat to safety, a major disruption to campus services, and once-monthly tests.
4. Download the Rave Guardian app to your phone. (https://www.clemson.edu/cusafety/cupd/rave-guardian/)
5. Learn what you can do to prepare yourself for the hazards that affect our locations. (http://www.clemson.edu/cusafety/EmergencyManagement/)

The professor reserves the right to modify any aspect of the syllabus at any time during the semester.