COLLEGE OF ENGINEERING, UIC

CS494, Introduction to High Performance Computing

Credit Hours: 4/3 Graduate/Undergraduate

I INSTRUCTOR and COURSE DETAILS

Michael E. Papka

Instructor Email: papka@uic.edu
Office: ERF 2028E
Office Hours: Tuesday and Thursday, 01:00 - 01:50 PM and by appointment
Phone: (630) 252-1556 (Office at Argonne)

Course Modality and Schedule

Modality: In Person
Schedule: Tuesday and Thursday, 2:00 PM to 3:15 PM
Location: ARC 239

II COURSE INFORMATION

Course Description

How are airplanes built without a physical prototype? How do we understand the evolution of the universe, or how are new cancer treatments identified for initial testing? Big problems require big computers - this course is meant to provide a general introduction to high performance computing and its role in today's world. This course will discuss the components of supercomputers, how they are organized, and the challenges in developing massive heterogeneous systems.

Prerequisite(s): CS 251 - Data Structures - *working knowledge of C/C++*

Course Goals and Learning Outcomes

The primary goal of this course is to offer a comprehensive introduction to high performance computing (HPC) and its applications in addressing complex, large-scale issues in various disciplines. It aims to equip students with a thorough understanding of supercomputers' components and organizational structures and expose them to the challenges and considerations of developing and utilizing massive heterogeneous systems. Additionally, the course provides a foundational understanding of HPC architecture, parallel computing systems, and software techniques. This introductory course provides the foundation for students to learn about HPC capabilities for advanced research and problem-solving across various disciplines. It underscores the importance of practical skill development through targeted programming assignments that provide an initial hands-on experience with parallel processing systems, positioning students to effectively apply their burgeoning knowledge to real-world challenges.

Learning Outcomes:

- **Understand HPC and Its Role:** Describe how high performance computing impacts various big problem-solving domains such as aerospace, medicine, and science. Explain the role and significance of supercomputers in contemporary research and development.
- **Comprehend HPC Architecture:** Identify and explain the fundamental architectural components of shared-memory and distributed-memory systems. Understand the organization and functioning of supercomputers.
- **Parallel Computing and Software Techniques:** Explain the basic principles of parallel computing. Understand and apply different paradigms, algorithms, and languages to program parallel systems.
- **Practical Application and Programming:** Develop and implement programs that utilize parallel processing systems. Use HPC resources effectively to solve computational problems.
- **Critical Thinking and Problem Solving:** Analyze and evaluate different HPC solutions for various complex scenarios. Apply critical thinking to assess the performance and efficiency of HPC systems and programs.
- **Knowledge Application Across Disciplines:** Demonstrate the ability to utilize HPC in various STEM fields, appreciating its potential to accelerate discovery and innovation.

Required and Recommended Course Materials:

- **Required Textbook(s):**
  - T. Sterling, M. Anderson, and M. Brodowicz, *High Performance Computing Modern Systems and Practices*, Morgan Kaufmann Publishers, 2018. [**main source of course material**]
- **Required Material(s):**
  - A **laptop is needed for this class** to take online quizzes and exams. A laptop would also be helpful to allow for participation in class hands-on activities.
  - Computing accounts on remote high performance systems, information on getting accounts will be provided in class.
- **Recommended Website(s):**
  - cplusplus.com: reference site with examples
  - OpenMP: official OpenMP site, includes the standardization effort
  - MPI: official MPI standardization site
  - Advanced Cyberinfrastructure for Education and Research UIC HPC center
  - Argonne Leadership Computing Facility: DOE Office of Science supercomputing center
- **Recommended Tool(s):**
  - Visual Studio Code: modern editor
  - Emacs: classic editor

Respect for Copyright:

By enrolling in this course, you are committing to uphold the integrity of all course materials, including exam and quiz questions, worksheets, lecture videos, presentations, and reading materials. Please respect the substantial effort put into creating these resources and avoid uploading or sharing them with individuals not enrolled in the course. Your adherence to these guidelines is essential for preserving the quality and confidentiality of our educational content. You **may NOT record lectures** without the instructor's permission.

III COURSE POLICIES and CLASSROOM EXPECTATIONS

Grading Policy and Point Breakdown

The course will be lecture-based, introducing the proposed topics. Additional pointers will be provided to online supplemental material to reinforce topics covered. There will be **two exams**, **weekly programming snippets** and/or **quizzes**, and **three projects** to implement the concepts presented in class. Graduate students in the class will have an **additional project**.

Undergraduate Student (3 credit hours)

Assignments	30%	missing assignments **impact final grade**
Weekly Snippets/Quizzes & Participation	30%	no late snippets, no makeup quizzes
Exam00	20%	first half of course material
Exam01	20%	second half of course material

Graduate Student (4 credit hours)

Assignments	30%	missing assignments **impact final grade**
Grad Project	10%	missing project **impact final grade**
Weekly Snippets/Quizzes & Participation	20%	no late snippets, no makeup quizzes
Exam00	20%	first half of course material
Exam01	20%	second half of course material

General Policies

- This course uses *Slack* (www.slack.com) for most of the course communication.
- All quizzes and exams are closed books and closed notes unless otherwise noted.
- **No makeup snippets[1], quizzes[1], or exams will be given.**
- You are responsible for all material presented in class and assigned readings. If you miss a lecture, obtain class notes from a classmate before the next class meeting.
- Course documents, including lecture notes, will be shared on the *class website*, and sample code will be within the course repository on *GitHub* on a best-effort basis. This means I am not promising when the posting will occur or if it will even occur. You are responsible for taking notes you think you will need to succeed in the class.

Assignments Policies

- The coding assignments for this course must tested on the resources used for the class. You may develop your code anywhere, but **grading of the assignments will be done on class resources**, so make sure your code works on them. Any computer assignment submitted for grading containing compile-time errors will receive zero points.

[1]Snippets and quizzes are over-allocated, so missing one or two will not impact your grade.

- The following statement must be included in any file you modify; it is your commitment that the work submitted is your own. Failure to include will result in a lower grade.

Listing 1: Required DocBox for any Files You Write or Modify

```
/*
    <Your Name>
    <Assignment>
    <Date>

    I certify that this is my own work and, where appropriate, an
       extension of the starter code provided for the assignment.
*/
```

Late Work Policy

Assignments submitted late will incur a deduction of 10% per day, including weekends and university holidays, from the maximum possible score. Submissions beyond three days late will result in a score of 0. Each missing assignment will initially reduce your grade by **50 points** [*reflected as -50 points in Blackboard*]. However, to mitigate this penalty, late submissions can be turned in for a grade of zero until the Monday of the final week of the semester, effectively removing the negative points.

Penalty Credit Policy

This course operates under a penalty credit policy; while attendance and class participation are not explicitly rewarded, they are expected and will influence your grade. Excused absences are considered; one grace absence is allowed per fifteen class meetings. Any unexcused absences beyond the grace allowance may lead to a 1% deduction from your final grade for each instance. Participation, or lack thereof, will also be considered when determining borderline final grades. Failure to complete assignments or projects will result in half a letter grade deduction per missing item. You have until the Monday of the last week of the semester (excluding finals week) to submit any outstanding assignments or projects for a grade of zero, which is preferable to the more substantial half-letter grade deduction.

Extra Credit Policy

Extra credit opportunities, accessible to all students, will be announced periodically in class or through Slack. Students must stay attentive to these announcements, as each extra credit task has a strict deadline.

Student Assessment Policy

Percentage	Points	Grade
$\geq$90	900	A
$\geq$80	800	B
$\geq$70	700	C
$\geq$60	600	D
$<$60	-	F

Additional Information about Student Assessment:

- Grades will be maintained in **UIC Blackboard**; please notify the instructor ASAP if you see an error. Students are responsible for tracking their progress via the online gradebook.
- Best effort will be made to keep the gradebook current. I will try to post grades within two weeks of exam/quiz/assignment due dates. Please **do not ask when grades will be posted**.

Other Course Policies

Academic Integrity

Good academic work is founded on honesty. Presenting work not personally produced is a grave offense. Cheating includes copying from others during exams or submitting work partly or entirely written by another. Plagiarism, whether intentional or not, occurs when students fail to acknowledge the sources of copied or paraphrased materials. All students should review the UIC Community Standards and Academic Integrity Policy.

- Everything that you do in this course must reflect your work. If you copy all or part of someone else's work, no matter where or how you get it, it will be considered cheating. Copying code from a website is considered an act of cheating.
- This is not to discourage discussions among classmates. However, discussions should not be as extensive and detailed as to border on collaboration and should be done in an open and inclusive space such as on *Slack*.

A student found responsible for academic dishonesty is subject to disciplinary action. (see Student Disciplinary Policy)

Generative AI Use Policy[2]

In this course, we recognize the potential of generative AI as a tool to enhance learning and innovation. As such, students are permitted to use generative AI for coding snippets, projects, and other course-related activities under the following conditions:

- **Transparency:** Students **should** disclose the use of generative AI in their submissions. The extent and nature of the AI's contribution should be clearly stated.
- **Learning, Not Replacing:** Generative AI should be used to aid understanding and augment research, not as a substitute for your learning or problem-solving.
- **Prohibited During Assessments:** Generative AI is strictly prohibited in quizzes, exams, and other assessment forms where individual understanding is being tested.
- **Ethical Use:** Students are expected to use AI responsibly, adhering to ethical guidelines and avoiding any form of academic dishonesty.
- **Scope of Policy:** This **policy applies solely to this course**. Other courses, departments, or university-wide policies may differ, and the student must adhere to those.

Violation of these guidelines may result in academic penalties as outlined in the course and the university's academic integrity policy. This policy is subject to review and modification as the technology and institutional guidelines evolve.

Electronic Communication

Students are responsible for reading messages sent to their @uic.edu account and communications on the Slack workspace. The course instructor will attempt to respond to the course-related messages sent to either the instructor's @uic.edu address or on Slack in a timely manner.

- The **course website** will house course material, the UIC Blackboard site will be used for posting grades, and there will be **little to no email** beyond initial announcements.

[2] Initial draft of policy generated by ChatGPT

- Assignment handouts will be distributed as a PDF or as a README in the GitHub repository for the assignment.
- If additional information for an assignment is needed, it will be posted in the assignments *Slack* channel; you are responsible for watching the course *Slack* channel daily. You can set up notifications on desktop and mobile applications of *Slack*.

IV CLASSROOM SCHEDULE

Please note that the schedule[3] is subject to change. Please check the online schedule for the latest assignments and readings. The schedule adheres to the university's academic calendar and final exam schedule.

Disclaimer: While every attempt is made to provide an accurate overview of the course, unanticipated circumstances or events may make it necessary to modify the syllabus during the semester. Adjustments may be made to account for student progress, experiences, needs, or other unforeseen outside factors. Any changes will be made with as much advance notice as possible not to disadvantage students. Please refer to the current version of Slack for the most up-to-date information.

V ACCOMMODATIONS

Disability Accommodation Procedures

UIC is committed to full inclusion and participation of people with disabilities in all aspects of university life. If you face or anticipate disability-related barriers while at UIC, please connect with the Disability Resource Center (DRC) at drc.uic.edu, via email at drc@uic.edu, or call (312) 413-2183 to create a plan for reasonable accommodations. To receive accommodations, you must disclose the disability to the DRC, complete an interactive registration process with the DRC, and provide me with a Letter of Accommodation (LOA). Upon receipt of an LOA, I will gladly work with you and the DRC to implement approved accommodations.

Religious Accommodations

I will make every effort to avoid scheduling exams or requiring student projects to be submitted on religious holidays. If you wish to observe your religious holidays, please notify me by the *tenth day of the semester* of the date when you will be absent unless the religious holiday is observed on or before the tenth day of the semester. In such cases, please notify me at least five days in advance of the date when you will be absent. I will try to honor your request and not penalize you for missing the class. If an examination or project is due during your absence, you will be given an exam or assignment equivalent to the one completed by those students in attendance. Students may appeal through campus grievance procedures for religious accommodations.

VI CLASSROOM ENVIRONMENT

Student Behavior

Students are expected to adhere to the UIC Community Standards within the classroom settings. This includes following university protocols for UIC COVID-19 Guidance for Students. Faculty may ask students

[3] Schedule is on the last page of syllabus

to leave if the faculty member(s) determines that community standards have been violated and a student is creating an environment that is unsafe or not conducive to learning.
In addition, our class (in person and online) will follow the CS Code of Conduct. If you are not adhering to our course norms, a case of behavior misconduct will be submitted to the Dean of Students and the Director of Undergraduate Studies in the Computer Science department. If you are not adhering to our course norms, you will not get full credit for your work in this class. Credit for the course will not be given for extreme cases of violating the course norms.
Please do not cause distractions that detract from your fellow student's learning; if the course is online, please mute yourself when you are not actively participating in a lecture. Please note that not participating in lectures (e.g., working on another assignment during a lecture) will affect your learning and the class participation portion of your grade.

Inclusive Learning Environment

UIC values diversity and inclusion. Regardless of age, disability, ethnicity, race, gender, gender identity, sexual orientation, socioeconomic status, geographic background, religion, political ideology, language, or culture, we expect all members of this class to contribute to a respectful, welcoming, and inclusive environment for every other member of our class. If there are aspects of the instruction or design of this course that result in barriers to your inclusion, engagement, accurate assessment, or achievement, please notify me as soon as possible.

Self-Care Statement

These are extremely stressful times. You are not alone in feeling it. We live with unsettling uncertainty that affects how we perceive the world, ourselves, and others. Such feelings may be persistent or may come on suddenly. Let's all promise to be patient with each other and help support a healthy learning environment. Do not hesitate to reach out if you or somebody you know is struggling with anxiety or other issues. Counseling Services are available for all UIC students. You may seek free and confidential services from the Counseling Center at counseling.uic.edu. The Counseling Center is in the Student Services Building; you may contact them at (312) 996-3490 during normal business hours (M-F, 9:00 AM - 5:00 PM). If calling after hours, press 2 to be connected to a crisis counselor. In addition to offering counseling services, the Counseling Center also operates the InTouch Crisis Hotline from 6:00 p.m. to 10:30 p.m. They offer support and referrals to callers and telephone crisis interventions; please call (312) 996-5535.

Multilingual Student Statement

I am committed to making course content accessible to all students. If English is not your first language and this causes you to be concerned about the course, please let me know.

Name Statement

Class rosters and university data systems are provided to faculty with the student's legal name and gender marker. As a UIC student, you can change how your preferred/proper name shows up on class rosters. This option is helpful for various student populations, including but not limited to students who abbreviate their first name, students who use their middle name, international students, and transgender students. As a faculty member, I am committed to using your proper name and pronouns. Please advise me if there are any changes.

Sexual Misconduct Statement

UIC is committed to ensuring your learning and work environment is the safest possible and a community free from all forms of sex discrimination, including sexual assault. Learn more about resources if you or someone you know has experienced sexual misconduct and explore the resolution processes.

VII RESOURCES: Academic Success, Wellness, and Safety

We all need the help and the support of our UIC community. Please visit my drop-in hours for course consultation and other academic or research topics. For additional assistance, please get in touch with your assigned college advisor and visit the support services available to all UIC students.

- **Academic Success**
  - UIC Tutoring Resources
  - College of Engineering Learning Center
  - Equity and Inclusion in Engineering Program
  - UIC Library and UIC Library Research Guides.
  - Offices supporting the UIC Undergraduate Experience and Academic Programs.
  - Student Guide for Information Technology
  - First-at-LAS Academic Success Program, focusing on LAS first-generation students.
- **Wellness**
  - ***Counseling Services:*** You may seek free and confidential services from the Counseling Center at https://counseling.uic.edu/.
  - Access U&I Care Program for assistance with personal hardships.
  - ***Campus Advocacy Network:*** Under Title IX, you have the right to an education free from any form of gender-based violence or discrimination. Email TitleIX@uic.edu to make a report. For more information or confidential victim services and advocacy, visit UIC's Campus Advocacy Network at http://can.uic.edu/.
- **Safety**
  - UIC Safe App — **PLEASE DOWNLOAD FOR YOUR SAFETY!**
  - UIC Safety Tips and Resources
  - Night Ride
  - ***Emergency Communications:*** By dialing 5-5555 from a campus phone, you can summon the Police or Fire for any on-campus emergency. You may also set up the complete number, (312) 355-5555, on speed dial on your cell phone.

Schedule

Day	L	Content	Snippets/Quizzes	Readings	Projects
T 01/09	00	Welcome	Survey		
Th 01/11	01	Class Tools and Resources I	C++/Make	Chapter 01	
T 01/16	02	Introduction and History HPC			
Th 01/18	03	Class Tools and Resources II	HPC Accounts		
T 01/23	04	Architecture		Chapter 02	Lego
Th 01/25	05	Architecture II	Git/GitHub	Chapter 03	
T 01/30	06	Benchmarking and Resource Management		Chapter 04/05	
Th 02/01	07	Threads and Creating Graphs	Quiz00		
T 02/06	08	OpenMP I		Chapter 07	OpenMP
Th 02/08	09	OpenMP Hands-On I	OpenMP I		
T 02/13	10	OpenMP II			
Th 02/15	11	OpenMP Hands-On II	OpenMP II		
T 02/20	12	OpenMP III			
Th 02/22	13	OpenMP Hands-On III	OpenMP III		
T 02/27	14	Review00	Quiz01		
Th 02/29	–	Exam00			
T 03/05	15	Algorithms and Debugging		Chapter 09/14	
Th 03/07	16	Checkpointing and Performance	Quiz02	Chapter 20/13	
T 03/12	17	Visualization		Chapter 12	
Th 03/14	–	Field Trip			
T 03/19	–	University Closed			
Th 03/21	–	University Closed		Chapter 08	
T 03/26	18	MPI I			MPI
Th 03/28	19	MPI Hands-On I	MPI I		
T 04/02	20	MPI II			
Th 04/04	21	MPI Hands-On I	MPI II		
T 04/09	22	MPI III			
Th 04/11	23	MPI Hands-On I	MPI III		
T 04/16	24	Future of HPC		Chapter 21	
Th 04/18	–	Graduate I	Quiz02		
T 04/23	–	Graduate II			
Th 04/25	25	Final Exam Review	Quiz03		
M 04/29	–	Final Exam			

Papka's Travel Schedule

- 02/20/2024 Australia
- 02/22/2024 Australia