ITCS 6145/8145 - Parallel Computing

Jinzhen Wang

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1 Course info

Term	Fall 2024
Course Title	ITCS 6145/8145 - Parallel Computing
Class Schedule	04:00 PM - 05:15 PM Mon & Wed
Class Location	Burson Hall, Room 115
Prerequisite Course	N/A
Course Instructor	Jinzhen Wang
Contact Email	`jwang96@charlotte.edu`
Office	Woodward Hall, Room 210B
Office Hour	03:00 PM - 04:00 PM Mon & Wed or by appointment
Course Link	`https://uncc.instructure.com/courses/229308`
Slack Group	`https://join.slack.com/t/itcs61458145p-fcl7468/shared_` `invite/zt-2owrwcl8j-lypTLKX4beLgBHCPHbAoOQ`

2 Generalities

This syllabus contains the policies and expectations I have established for this course. Please read the entire syllabus carefully before continuing in this course. These policies and expectations are intended to create a productive learning atmosphere for all students. Unless you are prepared to abide by these policies and expectations, you risk losing the opportunity to participate further in the course.

The standards and requirements set forth in this syllabus may be modified at any time by the course instructor. Notice of such changes will be by announcement in class, by email notice, or by changes to this syllabus posted on the course website on canvas.

2.1 Course Description

This course provides an in-depth exploration of parallel computing techniques, with a focus on single-node architectures. You will study shared memory models and GPU parallelism, developing the necessary skills to implement and optimize parallel algorithms on multi-core CPUs and many-core GPUs. The course covers theoretical concepts, practical programming approaches, and performance optimization strategies. You will engage in advanced projects and research to deepen the understanding and contribute to the field.

2.2 Prerequisites

You probably need the following to succeed in this course.

- A solid foundation in computer architecture and programming

- Proficiency in C/C++

- Understanding of basic algorithms and data structures

- Familiarity with operating systems and concurrency concepts

2.3 Learning Outcomes

At the end of this class, you will be able to

- represent and analyze a parallel algorithm

- modify an algorithm for making a parallel execution possible

- program a parallel algorithm on a shared memory machine

- identify common problem that prevent the correct execution of a program in parallel

- use modern data structures that are lock free or wait free

- take advantage of accelerators, such as GPUs, present in modern machines

By the end of this course, students will be able to:

- Understand and implement shared memory parallelism using multi-threading and synchronization techniques.

- Apply GPU programming models (CUDA/OpenCL) for high-performance computing tasks.

- Optimize parallel algorithms for performance on single-node systems.

- Conduct independent research and contribute original findings to the field of parallel computing.

2.4 Reading materials

No textbook is required, but some reading materials are recommendated.

Additional Resources:

- Research papers on hybrid computing models and performance optimization techniques

- Online tutorials and documentation on CUDA, OpenMP, and parallel algorithms

2.5 Instructor & TA

Instructor: Jinzhen Wang, jwang96@charlotte.edu
Office Location and Hours: Woodward 210B; 03:00 PM - 04:00 PM Mon & Wed.
Book an appointment here.

Teaching Assistant:
Office Location and Hours:

3 Course Topics (tentative)

- Module 1: Introduction to Parallel Computing

- Module 2: Parallel Computing Theory

- Module 3: Introduction to Shared Memory Programming

- Module 4: Pthread Programming

- Module 5: OpenMP Programming

- Module 6: CUDA Programming

- Module 7: Introduction to Distributed Memory Programming

- Module 8: Distributed Memory Programming using MPI

4 Course Policies

Per university policy, this 3-credit course expects 9 hours of student work each week for approximately 15 weeks. Student work may include but is not limited to: REQUIRED READING, LIBRARY RE-SEARCH, STUDIO WORK, PRACTICA, INTERNSHIPS, WRITTEN ASSIGNMENTS, AND STUDY-ING FOR QUIZZES AND EXAMS.

Students are expected to attend every class and remain in class for the duration of the session. Failure to attend class or arriving late may impact your ability to achieve course objectives which could affect your course grade. An absence, excused or unexcused, does not relieve a student of any course requirement. Regular class attendance is a student's obligation, as is a responsibility for all the work of class meetings, including tests and written tasks. Any unexcused absence or excessive tardiness may result in a loss of participation points.

The authority to excuse a student's class absence(s) and to grant a student an academic accommodation (turn in a late assignment(s), provide extra time on an assignment, reschedule an exam(s) etc.) sits with the individual instructor. Students are encouraged to work directly with me regarding their absence(s). The Dean of Students Office can assist faculty members in the verification a student's class absence(s) for documented situation related to medical, psychological, personal crisis, or military absences.

If I am late in arriving to class, you must wait a full 20 minutes after the start of class before you may leave without being counted absent, or you must follow any written instructions I may give you about my anticipated tardiness.

I will conduct this class in an atmosphere of mutual respect. I encourage your active participation in class discussions. Each of us may have strongly differing opinions on the various topics of class discussions. The conflict of ideas is encouraged and welcome. The orderly questioning of the ideas of others, including mine, is similarly welcome. However, I will exercise my responsibility to manage the discussions so that ideas and argument can proceed in an orderly fashion. You should expect that if your conduct during class discussions seriously disrupts the atmosphere of mutual respect I expect in this class, you will not be permitted to participate further.

The use of cell phones, smart phones, or other mobile communication devices is disruptive, and is therefore prohibited during class unless otherwise explicitly communicated for course purposes (e.g., use of clicker software from your smart phone). Except in emergencies, those using such devices must leave the classroom for the remainder of the class period. If unique circumstances are anticipated that necessitates the use of

such devices, the course instructor should be notified prior to class to discuss proper etiquette given the unique circumstances. Each non-emergency occurrence will be counted as an unexcused absence.

Students are permitted to use computers during class for note-taking and other class-related work only. Those using computers during class for work not related to that class must leave the classroom for the remainder of the class period. Each such occurrence will be counted as an unexcused absence.

In this course, students are permitted to use generative artificial intelligence (AI) tools (including but not limited to GitHub Copilot, ChatGPT, Gemini, Claude, Jasper AI, Character.ai, DALL-E, OpenAI API, Synthesia, Otter.a, .etc) to support their work. To maintain academic integrity, students must disclose any AI-generated material they use and properly attribute it, including in-text citations, quotations, and references (see, for example, https://apastyle.apa.org/blog/how-to-cite-chatgpt). Be aware that students are responsible for any errors or information that is misrepresented or inaccurate (i.e. hallucinations) that generative AI tools produce when submitting work that includes AI-generated material.

Students should also include the following statement in their assignments to indicate use of a generative AI tool: "The author(s) acknowledges the use of [generative AI tool Name] in the preparation or completion of this assignment. The [generative AI tool Name] was used in the following way(s) in this assignment: [e.g., brainstorming, grammatical correction, citation, which portion of the assignment]."

Important Note on Data Protection and Privacy: When using generative AI tools, it is important to be aware that the data you supply might be used for training AI models or other purposes. Consequently, there is no guarantee that the information you provide will remain confidential. You should exercise caution and avoid sharing any sensitive or private information when using these tools. Examples of such information include personally identifiable information, protected health information (PHI), financial data, intellectual property, original research, and any other data that might otherwise be legally protected.

Instructor's note: It is strongly recommended to use such tools with caution, but the reasons listed below:

- These tools are not perfect. They can be wrong;

- "Overdosing" on them eliminates the chances of understanding and individual thinking;

4.1   Grading

Grading will be based on an absolute scale. The precise breakdown might change depending on how many activities are actually given and other unforeseeable events.

Table 1: Grade Distribution

Assignments	30%
In-class Quizs	10%
Two Midterms	30%
One Final Exam	30%

4.2   Assignment & Project Submissions

Canvas will be used for assignment and project submissions. **No assignments will be accepted by email.**

4.3 Late submission policy

Assignments are usually due a week after they have been released. If the assignment due date is a date where we have a class, the assignment is due BEFORE class starts.

Assignment can be submitted up to one week late; but a late submission penalty applies. If an assignment is submitted L dayes late, then the maximum achievable grade for that assignment is $100 - 3 * L$. One minute late, is one day late. Canvas submission time will be used to determine if an assignment is on time or late.

For instance, if a student turns in an assignment 2 days late and would have scored 100, he/she will receive 94. If an other student is 7 days late and would have scored 60, he/she will receive 60.

I understand that things will happen. Therefore, you have 2 credits throughout the semester for late submissions without penalty, PLAN YOUR ACTIVITIES WELL. Any late submission beyond will subject tot he late submission policy above.

4.4 Obtaining help

It is expected in this class that many students will need to obtain help during the course of the semester. Especially in the early weeks where a new environment is introduced.

The instructor and the TA are the best resource. Feel free to get in touch, we are here to help. But your peers can help to in some measure.

If you have a general question about the class, a particular point you are unsure of, the best place to ask is the Canvas discussion board and Slack group (TBA). Using the Canvas discussion board and Slack enables your peer to potentially answer the question and builds in a place where questions you have may already have been answered.

The instructor and the TAs are available during their office hours. Take advantage of them: direct interactions often help understand hidden problems. Office hours may not fit your schedule. So if you need to meet outside of office hours then feel free to contact us by email to obtain an appointment.

If you have questions that are related to your particular case, such as questions about your grades or a fine point on a programming assignment that would require you to disclose your entire assignment, then feel free to ask those by email. **We may redirect questions that can serve the whole class to the Canvas Discussion board**.

5 University Policies

5.1 Tardiness or Absenteeism

Class Absence(s): The authority to excuse a student's class absence(s) and to grant a student an academic accommodation (turn in a late assignment(s), provide extra time on an assignment, reschedule an exam(s) etc.) sits with the individual instructor. Students are encouraged to work directly with their instructors regarding their absence(s). Note: The Dean of Students Office can assist faculty members in the verification a student's class absence(s) for documented situation related to medical, psychological, personal crisis, or military absences.

5.2   Academic Integrity, Plagiarism

All students are required to read and abide by The Code of Student Academic Integrity. Violations of the Code of Student Academic Integrity, including plagiarism, will result in disciplinary action as provided in the Code. Definitions and examples of plagiarism are set forth in the Code. The Code is available from the Dean of Students Office or online at: `http://legal.uncc.edu/policies/up-407`. The code will be strictly enforced and is binding on the students. Grade and academic evaluations in this course include a judgment that the student's work is free from academic dishonesty of any type; and grades in this course therefore should be and will be adversely affected by academic dishonesty. Students who violate the code can be expelled from UNC Charlotte. The normal penalty for a first offense is zero credit on the work involving dishonesty and further substantial reduction of the course grade. In almost all cases the course grade is reduced to an F.

Faculty may ask students to produce identification at examinations and may require students to demonstrate that graded assignments completed outside of class are their own work. As a condition of taking this course, all required projects and assignments may be subject to submission for textual similarity review to VeriCite (or other similar services, like MOSS or TurnitIn) for the detection of plagiarism. All submitted projects will be included as source documents in the service reference database solely for the purpose of detecting plagiarism of such projects. No student papers will be submitted to this service without a student's written consent (http://teaching.uncc.edu/sites/teaching.uncc.edu/files/media/VeriCite/VeriCite Limited Copyright Permission and FERPA Disclosure Consent Form.pdf) and permission. If a student does not provide such written consent and permission, the instructor may: (i) require a short reflection paper on research methodology; (ii) require a draft bibliography prior to submission of the final paper; or (iii) require the cover page and first cited page of each reference source to be photocopied and submitted with the final paper.

5.3   Withdrawals

Students are expected to complete all courses for which they are registered at the close of the add/drop period. If you are concerned about your ability to succeed in this course, it is important to make an appointment to speak with the instructor as soon as possible. The University policy on withdrawal allows students only a limited number of opportunities available to withdraw from courses. It is important for you to understand the financial and academic consequences that may result from course withdrawal (http://provost.uncc.edu/policies/academic/withdrawals).

5.4   Inclusivity

Preferred Gender Pronoun: This course affirms people of all gender expressions and gender identities. If you prefer to be called a different name than what is indicated on the class roster, please let me know. Feel free to correct me on your preferred gender pronoun. If you have any questions or concerns, please do not hesitate to contact me.

Non-Discrimination: All students and the instructor are expected to engage with each other respectfully. Unwelcome conduct directed toward another person based upon that person's actual or perceived race, actual or perceived gender, color, religion, age, national origin, ethnicity, disability, or veteran status, or for any other reason, may constitute a violation of University Policy 406, The Code of Student Responsibility. Any student suspected of engaging in such conduct will be referred to the Office of Student Conduct for possible conduct action.

5.5   Disability Accommodations

Students in this course seeking accommodations to disabilities must first consult with the Office of Disability Services and follow the instructions of that office for obtaining accommodations.

5.6 Sexual Harassment

All students are required to abide by the UNC Charlotte Sexual Harassment Policy and Grievance Procedures (available online at: http://legal.uncc.edu/policies/up-502) and the policy on Responsible Use of University Computing and Electronic Communication Resources (available online at: http://legal.uncc.edu/policies/up-307). Sexual harassment, as defined in the Sexual Harassment Policy and Grievance Procedures, is prohibited, even when carried out through computers or other electronic communications systems, including course-based chat rooms or message boards.

5.7 Title IX Reporting Obligations

UNC Charlotte is committed to providing an environment free of all forms of discrimination and sexual harassment, including sexual assault, domestic violence, dating violence, and stalking. If you (or someone you know) has experienced or experiences any of these incidents, know that you are not alone. UNC Charlotte has staff members trained to support you in navigating campus life, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders, and more.

Please be aware that many UNC Charlotte employees, including all faculty members, are considered Responsible Employees who are required to relay any information or reports of sexual misconduct they receive to the Title IX Coordinator. This means that if you tell me about a situation involving sexual harassment, sexual assault, dating violence, domestic violence, or stalking, I must report the information to the Title IX Coordinator. Although I have to report the situation, you will still have options about how your case will be handled, including whether or not you wish to pursue a formal complaint. Our goal is to make sure you are aware of the range of options available to you and have access to the resources you need.

If you wish to speak to someone confidentially, you can contact any of the following on-campus resources, who are not required to report the incident to the Title IX Coordinator: (1) University Counseling Center (counselingcenter.uncc.edu, 7-0311); (2) Student Health Center (studenthealth.uncc.edu, 7-7400); or (3) Center for Wellness Promotion (wellness.uncc.edu, 7-7407). Additional information about your options is also available at titleix.uncc.edu under the "Students" tab.