ECE 794, Parallel Computing, Spring, 2024

(Multithreaded Programing for High Performance Computer Systems)

- Instructor: Abu Asaduzzaman (DRZ)
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- Preferred Method of Contact: In person during office hours or e-mail
- Classroom, Day/Time: 314 Jardine Hall, Monday/Wednesday 5:05-6:20 PM
- Student/Office Hours: Mon/Wed 6:25-6:55 PM, Tue/Thu 8:00-9:00 AM
- Prerequisites: ECE 694 or instructor's consent
- Teaching Assistant (TA): Grading – To Be Decided (TBD)
- TA Contacts: Grading – tbd@shockers.wichita.edu

How to use this syllabus

This syllabus provides you with information specific to this course, and it also provides information about important university policies. This document should be viewed as a course overview; it is not a contract and is subject to change as the semester evolves. Any changes should be shared via lecture and/or Blackboard.

University Policies and Procedures

The Wichita State University Policies and Procedures Manual can be found at: https://www.wichita.edu/about/policy/.

Academic Integrity

Students at Wichita State University are expected to uphold high academic standards. WSU will not tolerate a lack of academic integrity. Students are responsible for knowing and following the Student Code of Conduct http://webs.wichita.edu/inaudit/ch8_05.htm and the Student Academic Honesty policy http://webs.wichita.edu/inaudit/ch2_17.htm. When the faculty member determines sanctions are warranted for violations of academic integrity, regardless of severity, the faculty member must report the infraction to the Office of Student Conduct and Community Standards. If you need more information about the process or wish to appeal a decision, please visit https://www.wichita.edu/about/student_conduct/ai.php

Homework (HW) assignments in this course are individual assignments (unless otherwise stated). Students can discuss with others, but they should not write solutions together; one's submission (wording/coding) should be reasonably different from others' submissions. "Collaboration is good, cheating is not!" There will be severe consequences for academic dishonesty. Cheating (such as copying word-for-word from other sources) in any test will automatically result a Fail grade in this course; this grading policy applies to all parties involved (including the ones who help/show).

Course Description

Introduces techniques with theory and syntax to program high performance computer systems for data analyses. Particular attention is given to the following areas: multicore/many-core architectures and multithreaded programming using application programming interfaces such as OpenMP, MPI, and CUDA. Programming assignments and team projects give hands-on experience.

Measurable Student Learning Outcomes

After passing this course, students will be able to:

- (SO: EAC 1) an ability to identify, formulate, and solve parallel computing problems by applying principles of engineering, science, and mathematics (*Here, SO is for Student Outcome and EAC is for Engineering Accreditation.*)
- Understand the concepts of contemporary multicore/many-core systems and parallel programming using OpenMP, Open MPI, and CUDA.
- (SO: EAC 7) an ability to acquire and apply new computing knowledge as needed, using appropriate learning strategies

Required Texts/Readings Textbook

Please talk to the instructor before buying books for this course.

Book: An Introduction to Parallel Programming, Pacheco and Malensek, Morgan Kaufmann, 2nd edition, 2020.

Reference 1: CUDA by Example: An Introduction to General-Purpose GPU Programming, Sanders and Kandrot, Addison-Wesley Professional, 1st edition, 2010.

Reference 2: Using MPI-2: Advanced Features of the Message Passing Interface, Gropp, Lusk, and Thakur, MIT Press, 1st edition, 1999.

Reference 3: Parallel Programming in OpenMP, Chandra, Menon, Dagum, Kohr, Maydan, and McDonald, Morgan Kaufmann, 1st edition, 2000.

Other Readings

Class notes, reading materials (on OpenMP, MPI-2, and CUDA), and code examples will be made available via WSU Blackboard.

Other Equipment/Materials

Students will be provided information about parallel computing servers and service supports so that they can work on programming assignments and projects. More information will be provided during class lectures as may require.

Class Protocol

There are points on class performance. It is expected that students join the instructor and/or TA before classes start. Students are always encouraged to ask questions, especially if they find ambiguity in assignments and materials covered.

Contact Policy

Although you may attempt to reach me by phone, email communication is always preferred. Feel free to email me any questions or concerns following these guidelines:

- **Always** email me from your WSU email address. Email sent from personal email servers like Gmail, Yahoo, etc., have a tendency to end up in my spam folder, and I never see them. You may also email me through Blackboard via the Email My Instructor tab. I also offer a Discussion Forum on Blackboard which allows common questions to be seen and responded to publicly.
- Always use the course name in the subject line of the email.
- Remember to sign your name.
- If you have a problem with accessing or uploading assignments, you should let me know as soon as possible before the assignment is due. You will also have to accompany this notification with the file in question, so I can verify that it is completed by the due date/time.
- You **should NOT** contact me for tech support.
    - Any technical problems involving your computer, or issues regarding file uploading or sharing, should go through the OneStop. You can contact them at 316-978-3909. You can also fill out a request for help form at their website: https://wichita.edusupportcenter.com/sims/helpcenter/common/layout/SelfHelpHome.seam?inst_name=wichita

Response Time

To Email and Discussion Forum Questions:

As soon as possible within 24 hours. If you do not receive reply to your email within 24 hours, please re-send me the email, probably the email did not arrive to my Inbox.

Grading Scale

WSU uses a +/- grading scale for final grades and to calculate grade point averages. In this class, grades are assigned according to the following chart. (Other classes might assign grades differently: Be sure to understand the different grading scales in all of your classes.)

Points/Percentage	Letter Grade	Grade Points	Interpretation
93 and up	A	4.00	A range denotes excellent performance
90 – less than 93	A-	3.70	
87 – less than 90	B+	3.30	
83 – less than 87	B	3.00	B range denotes good performance
80 – less than 83	B-	2.70	
77 – less than 80	C+	2.30	
73 – less than 76	C	2.00	C range denotes satisfactory performance
70 – less than 73	C-	1.70	
67 – less than 70	D+	1.30	
63 – less than 67	D	1.00	D range denotes unsatisfactory performance
60 – less than 63	D-	0.70	
0 – less than 60	F	0.00	

Assignments (and Grading Scale)

While determining letter grades, the same grading scale will be used for undergraduate and graduate students. List of grading assignments/components and values toward the final letter grades are shown below. Homework assignments and their due dates will be announced in class and/or made available via Blackboard. Similarly, the dates for Quiz, Exam, and Project will be announced in class and/or made available via Blackboard.

Grading Assignments/Components	Value
Class Attendance & Performance	4%
Homework/Programming (five of six, take home)	10%
Quiz (two of three, 30-minute, class-test)	14%
Exam-1 (~ Week 5, 65-minute, class-test)	16%
Exam-2 (~ Week 10, 65-minute, class-test)	16%
Project (Proposal, Presentation, and Report)	24% (4+8+12)
Exam-3 (cumulative, 65-minute, class-test)	16%

Feedback on Assignments:

As soon as possible after the due date including the late submission date/time. Answer key will be discussed in lecture sessions and/or shared via Blackboard.

Late Assignments

For homework assignments, late submissions will not be accepted after five days from the original due date/time. Up to 50% points may be subtracted for any late submission. Exceptions include documented emergency situations and prior consents.

Missed Tests and Labs/Projects

Makeup for missed tests (Quiz and Exam) and Labs/Projects) will be given only when there is a genuine reason, with clear proof. It is students' responsibility to provide the proof; if the reason for missing a test is illness, a doctor's note will be required. Students should contact the instructor before any makeup test.

Extra Credit

Extra credits are possible as/if needed. Depending on class performance after Week 10, if required, extra credit assignments and their due dates will be determined.

Undergraduate vs. Graduate Credit

Undergraduate students enrolled in 700 level courses will receive undergraduate credit (not graduate credit) unless they have a previously approved senior rule application or dual/accelerated enrollment form on file in the Graduate School. Undergraduate credit earned in 700 level courses cannot later be counted toward a graduate degree.

Teaching Assistants

Grading TA:

TBD <tbd@shockers.wichita.edu>

Office Hours/Room: TBD

The Grading TA (if any) is not allowed to solve student problems (any problem). The TA should grade test papers and provide feedback to students for any missing points. If students have any questions regarding the course materials or assignments, they should immediately contact the course instructor.

Syllabus Policies and Student Resources

All students should familiarize themselves with the course-related policies and student resources that can be found at: **www.wichita.edu/syllabuspolicies**

These include, but may not be limited to:

- COVID-19 Conditions
- Important Academic Dates

- Academic Integrity
- Definition of a credit hour
- Video and Audio recording
- Shocker Alert System
- Intellectual Property
- CARE Team
- Counseling and Prevention Services
- Student Health Services
- Heskett Center and Campus Recreation
- Inclusive Excellence and Respect for Diversity
- First Generation Students
- Names and Pronouns
- Disability Services
- Title IX
- Concealed Carry Policy

Students with Disabilities

A disability is something that affects a major life activity. These life activities include, but are not limited to, learning, walking, breathing, hearing, and seeing, in addition to many other physical, sensory functions, and psychological disabilities.

If you are a student with a disability, or believe you might have a disability, which requires accommodations, please contact the Office of Disability Services (ODS) www.wichita.edu/ods to discuss reasonable and appropriate accommodations and eligibility requirements. It is the University's goal that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability ODS will review your concerns and determine, with you, what academic accommodations are necessary and appropriate for you. For example, adaptions of teaching methods, class materials or testing may be made on a case-by-case basis if warranted, as required by the Americans with Disabilities Act (ADA). All information and documentation of your disability is confidential and will not be released by ODS without your written permission.

Respect for Diversity

Wichita State University is committed to being an inclusive campus that reflects the evolving diversity of society. To further that goal, Wichita State University does not discriminate in its employment practices, educational programs or activities on the basis of age (40 years or older), ancestry, color, disability, gender, gender expression, gender identity, genetic information, marital status, national origin, political affiliation, pregnancy, race, religion, sex, sexual orientation, or status as a veteran. Retaliation against an individual filing or cooperating in a complaint process is also prohibited.

Students from all diverse backgrounds and perspectives are welcome in this Course and the diversity that students bring to this course should be viewed as a resource, strength and benefit. All materials and activities are presented with the intent to be

respectful of diversity: gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture. Your suggestions are encouraged and appreciated. Please let me know ways to improve the effectiveness of the course for you personally or for other students or student groups. In addition, if any of our class meetings conflict with your religious events, please let me know so that we can make arrangements for you.

Laboratory Information

Students in this course will need to access Beoshock, the HPC cluster at WSU, for their programming needs. There is no teaching/research lab associated to this course; however, we will provide supports so that you can perform the programming assignments. Information about Beoshock (such as how to log in and how to run CUDA programs) will be provided via lectures. The main purpose of Beoshock is to provide students a HPC platform so that they can write/debug/run parallel programs for assignments and projects. If possible, we may meet in the Computer Architecture and Parallel Programming Laboratory (CAPPLab) in 312 Wallace Hall for additional help.

Brief List of Topics to Cover

Introduction and Motivation

- Sequential to Parallel Computing
- Why/How/What Parallel Computing?

Course Project

- Technical Reading, Writing, and Presentation
- Teamwork: Proposal (with literature review), Report, and Presentation

Parallel Hardware and Parallel Software

- SIMD and MIMD Systems; Shared- and Distributed-Memory
- Hardware Supports for ILP, TLP, SMT
- Performance – Execution Time, Speedup

Parallel Programming

- OpenMP (only for shared-memory systems)
- Open MPI (for distributed-memory systems)
- CUDA (for CPU-GPU systems)

Selected Topics

- Parallel Computing for Data Analytics
- Performance-Power Evaluation for Exascale Computing

Tentative Schedule

Week Tue	Note	Important topics/readings, assignments, due dates, and reminders are listed here so that you can organize your time and academic work.
1 01/17		ECE 794: Parallel Computing; Syllabus; K-probe; Project: Components, Groups, Grading; HW-1 Assign;
2 01/24	HW-1	Single-core to multicore arch; Project: Groups, Topics; HW-1 (Blackboard); Cache-memory hierarchy;
3 01/31	HW-2	Shared and distributed memory systems; Performance; HW-2 (Bb); Quiz-1 discussion;
4 02/07	Quiz-1	Sequential to parallel programming; Parallelism: ILP … SMT Quiz-1 (class test, 30-min / 30-pts, closed book);
5 02/14	Exam-1	Parallelism: ILP, PLP, TLP, SMP, SMT; Exam-1 discussion; EXAM-1 (class test, 65-min / 65-pts, closed book);
6 02/21	Update Project	Project: Technical reading, writing, and presentation; Project: **Proposal** with literature review due (Bb);
7 02/28	HW-3	Parallel Programming: OpenMP for shared-memory systems; HW-3 (Bb); Parallel Programming: MPI-2 for distributed memory sys;
8 03/07	HW-4 Quiz-2	OpenMP; MPI-2; Concurrency: SMT-enabled GPU systems; HW-4 (Bb); Quiz-2 (class test, 30-min / 30-pts, closed book);
9 03/14	Spr Brk	03/13-03/19 (Spring Break) No Class;
10 03/21	Exam-2	Parallel programming using OpenMP and MPI-2; EXAM-2 (class test, 65-min / 65-pts, closed book);
11 03/28	Update Project	GPU computing; CUDA (CPU-GPU) programming; Project: Report (format), Presentation (slides);
12 04/04	HW-5	CPU-GPU systems: Memory hierarchy; HW-5 (Bb); CUDA Programming: Threads/Blocks/Grids;
13 04/11	HW-6	CUDA (CPU-GPU) programming; Thread co-operations; HW-6 (Bb); Quiz-3 discussion;
14 04/18	Quiz-3	Applications of CUDA (CPU-GPU) programming; Quiz-3 (class test, 30-min / 30-pts, closed book);
15 04/25	Project	Project **Presentation**: Team-work, PowerPoint slides; Final **Report**: Team-work, via Blackboard on Friday;
16 05/02	Exam-3	Review materials for Exam-3; EXAM-3 (class test, 65-min / 65-pts, closed book);
Finals		None!
Note: A date in Column 1 indicates the Tuesday of that week. Here, 05/02 is Tuesday of Week 16.		

1) *December 21, 2022; prepared for spring 2024 term; DRZ*

Definition of a Credit Hour (https://www.wichita.edu/faculty/development/syllabuspolicies.php)

Example for 3 credit hour class: Success in this 3 credit hour course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally 3 hours per unit per week with 1 of the hours used for lecture) for instruction and preparation/studying or course related activities for a total of 135 hours.

Go to 4.08 / Definition and Assignment of Credit Hours for the policy and examples for different types of courses and credit hour offerings.