

CS 5334: Parallel and Concurrent Programming (ONLINE)

CRN: 28391

Spring 2021 4:30-5:50pm TR

Instructor: Shirley Moore

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<https://www.cs.utep.edu/svmoore/>

<https://github.com/mooresv/>

Office hours: Virtually via TEAMS, Tuesdays 3-4pm, Fridays 12-1pm, other times by appointment

Course Information: What this class is about and what we will do

COURSE DESCRIPTION

The goal of this course is to introduce students to the foundations of parallel programming, including the principles of concurrency, parallel algorithm design, programming models for shared and distributed memory systems, numerical and non-numerical parallel algorithms, analytical modeling of parallel programs, and debugging and performance optimization of parallel programs. The course will include material on emerging parallel hardware, new shared-memory and accelerator programming models, and emerging parallel and distributed machine learning applications. A key aim of the course is for students to gain hands-on experience by writing correct and efficient concurrent and parallel programs in some of the programming models covered in class.

COURSE PREREQUISITES

Programming experience in C/C++ and/or Fortran and/or Java, CS 2302 Data Structures, and CS 3432 Computer Architecture I; or CPS 5401; or permission of the instructor

LEARNING OUTCOMES

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

- DESCRIBE and APPLY concepts of concurrency and parallelism
- EXPRESS concurrent computations and their coordination correctly
- DESCRIBE the major approaches to parallelism used in a large parallel program
- DESIGN and IMPLEMENT a decomposition strategy and parallel algorithm to solve a given numerical or non-numerical problem
- SELECT and APPLY appropriate parallelization constructs to a large program to create a correct parallel version that exploits a state-of-the-art parallel computing environment
- ASSESS the correctness of concurrent and parallel programs
- APPLY available debugging methods to detect and correct errors in concurrent and parallel programs
- ASSESS the performance of a parallel program run with different input sizes and numbers of processors

- APPLY performance optimization methods to improve the parallel efficiency and scalability of a parallel program
- DISCUSS current and future trends in parallel architectures and programming models

LEARNING MODULES

This course is designed using a modular format—that is, each week is “packaged” as a module so that all the materials, lecture notes, recordings, and discussion posts are grouped together on Teams for a given week.

TEXTBOOKS

Programming on Parallel Machines: GPU, Multicore, Clusters and More, by Norm Matloff, University of California, Davis, freely available online at <http://heather.cs.ucdavis.edu/~matloff/158/PLN/ParProcBook.pdf>

(I suggest downloading a local copy of the book, since the website can sometimes be unreachable).

LRU: Mining of Massive Datasets, by Jure Leskovec, Anand Rajaraman, and Jeff Ullman, 3rd edition, Cambridge University Press, 2020. Downloadable from <http://mmds.org>

Other readings and materials will be posted in the weekly modules.

COURSE ASSIGNMENTS AND GRADING

Assignments for this course will be assessed according to rubrics.

Grade Distribution:

1000-900 = A 899-800 = B 799-700 = C 699-600 = D 599 and Below = F

- 250 points: Lab Assignments
- 200 Points: Midterm Exam 1
- 200 Points: Midterm Exam 2
- 200 Points: Term Project
- 150 Points: Participation

Lab Assignments: Lab assignments will be turned in to a private github site.

Midterm Exams: Midterm exams will assess achievement of the learning outcomes. Exams will be take-home due to the COVID-19 pandemic.

Term Project: The term project will be either an individual or a group project on a topic of your choice. The instructor will prepare a list of suggested topics, but you will be free to choose a different topic that interests you subject to instructor approval.

Participation: For this online course, students will be required to participate in weekly discussions – both an initial post and responses to your peers. Students will also have a collection of smaller assignments throughout the week that will build toward the larger lab assignments. Each of these activities will be given point values that add up to the total 150-point participation grade. These points cannot be made up, so students are expected to stay active in the course by posting at least five initial posts, responses, or homework answers a week.

TECHNOLOGY REQUIREMENTS

Course content will be delivered via the Internet through Microsoft Teams and the Blackboard learning management system. Ensure your UTEP e-mail account is working and that you have access to the Web and a stable web browser. Google Chrome and Mozilla Firefox are the best browsers for Blackboard; other browsers may cause complications. When having technical difficulties, update your browser, clear your cache, or try switching to another browser.

You will need to have access to a computer/laptop, scanner, a webcam, and a microphone. You will need to download or update the following software: Microsoft Office, Adobe Acrobat Reader, and Java. Check that your computer hardware and software are up-to-date and able to access all parts of the course.

If you do not have Microsoft Office, you can download Word and other Microsoft Office programs (including Excel, PowerPoint, Outlook and more) for free via UTEP's Microsoft Office Portal. Click the following link for more information about [Microsoft Office 365](#) and follow the instructions.

IMPORTANT: If you encounter technical difficulties beyond your scope of troubleshooting, please contact the UTEP [Help Desk](#) as they are trained specifically in assisting with technological needs of students. Please do not contact the instructor for this type of assistance. The Help Desk is much better equipped than I am to assist you!

COMPUTER SYSTEM ACCESS

For class activities, homework, and lab assignments that involve programming, we will use the Bridges CPU and GPU systems at Pittsburgh Supercomputing Center(PSC). The instructor has applied for and been granted an education allocation that has 10,000 CPU service units (SUs) and 2500 GPU SUs. Bridges is a resource available through XSEDE (<https://xsede.org/>). If you do not already have an XSEDE account, please go to <https://portal.xsede.org/> and create one. Then send email to the instructor with your XSEDE username so that she can add you to the class allocation. See the Bridges User Guide at [https:// www.psc.edu/resources/bridges/](https://www.psc.edu/resources/bridges/) for information about how to use Bridges.

Course Communication: How we will stay in contact with each other

Because this is an online class, we won't see each other face-to-face in the ways you may be accustomed to, such as during class time, small group meetings, and office hours. However, there are a number of ways we can keep the communication channels open:

- **Office Hours:** We will not be able to meet on campus, but I will still have office hours for your questions and comments about the course. My office hours will be held on Teams during the following times:

Tuesdays: 3-4 p.m. Mountain Time

Fridays: 12-1 p.m. Mountain Time

You may also make an appointment for a different time at my Calendly page at

<https://calendly.com/svmoore/> .

- **Email:** UTEP e-mail is the best way to contact me. I will make every attempt to respond to your e-mail within 24 hours of receipt. When e-mailing me, be sure to email from your UTEP student account and please put the course number in the subject line. In the body of your e-mail, clearly state your question. At the end of your e-mail, be sure to put your first and last name.
- **Online Discussion:** If you have a question that you believe other students may also have, please post it in the Chat in Teams. Please respond to other students' questions if you have a helpful response.
- **Announcements:** Check the Blackboard announcements frequently for any updates, deadlines, or other important messages. I will ask BlackBoard to email any announcements, so checking your email for announcements should also suffice.

NETIQUETTE

As we know, sometimes communication online can be challenging. It's possible to miscommunicate what we mean or to misunderstand what our classmates mean given the lack of body language and immediate feedback. Therefore, please keep these netiquette (network etiquette) guidelines in mind.

- Always consider the audience. This is a college-level course; therefore, all communication should reflect polite consideration of other's ideas.
- Respect and courtesy must be provided to classmates and to the instructor at all times. No harassment or inappropriate postings will be tolerated.
- When reacting to someone else's message, address the ideas, not the person. Post only what anyone would comfortably state in a face-to-face situation.
- Blackboard and Teams are not public internet venues; all postings to them should be considered private and confidential. Whatever is posted in these online spaces is intended for classmates and professor only. Please do not copy documents and paste them to a publicly accessible website, blog, or other space.

Course Policies: What do you need to do to be successful in the course

ATTENDANCE AND PARTICIPATION

Attendance in the course is determined by participation in the learning activities of the course. Your participation in the course is important not only for your learning and success but also to create a community of learners. Participation is determined by completion of the following activities:

- Reading/Viewing all course materials to ensure understanding of assignment requirements
- Participating in engaging discussion with your peers
- Participating in class sessions, or in the event that you are unable to attend a class and have an excused absence, viewing and commenting on the recording of the session
- Other activities as indicated in the weekly modules

Because these activities are designed to contribute to your learning each week, they cannot be made up after their due date has passed.

EXCUSED ABSENCES AND COURSE DROP POLICY

According to UTEP Curriculum and Classroom Policies, “When, in the judgment of the instructor, a student has been absent to such a degree as to impair his or her status relative to credit for the course, the instructor may drop the student from the class with a grade of “W” before the course drop deadline and with a grade of “F” after the course drop deadline.” See academic regulations in the UTEP Graduate Catalog for a list of excused absences. Therefore, if I find that, due to non-performance in the course, you are at risk of failing, I will drop you from the course. I will provide 24 hours advance notice via email.

DEADLINES, LATE WORK, AND ABSENCE POLICY

Lab Assignments

- Lab assignments will be due on Sundays at midnight (11:59 PM). No late work will be accepted if the reason is not considered excusable.

Quiz and Discussion Assignments

- All quiz and discussion assignments will be due on Sundays at midnight (11:59 PM). No late work will be accepted if the reason is not considered excusable.

MAKE-UP WORK

Make-up work will be given *only* in the case of a *documented* emergency. Note that make-up work may be in a different format than the original work, may require more intensive preparation, and may be graded with penalty points. If you miss an assignment and the reason is not considered excusable, you will receive a zero. It is therefore important to reach out to me—in advance if at all possible—and explain with proper documentation why you missed a given course requirement. Once a deadline has been established for make-up work, no further extensions or exceptions will be granted.

ALTERNATIVE MEANS OF SUBMITTING WORK IN CASE OF TECHNICAL ISSUES

I strongly suggest that you submit your work with plenty of time to spare in the event that you have a technical issue with the course websites, network, and/or your computer. I also suggest you save all your work (answers to discussion points, quizzes, exams, and programs) on a back-up. This way, you will have evidence that you completed the work and will not lose credit. If you are experiencing difficulties submitting your work through the course websites, please contact the UTEP Help Desk. You can email me your back-up document as a last resort.

INCOMPLETE GRADE POLICY

Incomplete grades may be requested only in exceptional circumstances after you have completed at least half of the course requirements. Talk to me immediately if you believe an incomplete is warranted. If granted, we will establish a contract of work to be completed with deadlines.

ACCOMMODATIONS POLICY

The University is committed to providing reasonable accommodations and auxiliary services to students, staff, faculty, job applicants, applicants for admissions, and other beneficiaries of University programs, services and activities with documented disabilities in order to provide them with equal opportunities to participate in programs, services, and activities in compliance with sections 503 and 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) of 1990 and the Americans with Disabilities Act Amendments Act (ADAAA) of 2008. Reasonable accommodations will be made unless it is determined that doing so would cause undue hardship on the University. Students requesting an accommodation based on a disability must register with the [UTEP Center for Accommodations and Support Services](#) (CASS). Contact the Center for Accommodations and Support Services at 915-747-5148, or email them at cass@utep.edu, or apply for accommodations online via the [CASS portal](#).

SCHOLASTIC INTEGRITY

Academic dishonesty is prohibited and is considered a violation of the UTEP Handbook of Operating Procedures. It includes, but is not limited to, cheating, plagiarism, and collusion. Cheating may involve copying from or providing information to another student, possessing unauthorized materials during a test, or falsifying research data on laboratory reports. Plagiarism occurs when someone intentionally or knowingly represents the words or ideas of another as ones' own. Collusion involves collaborating with another person to commit any academically dishonest act. Any act of academic dishonesty attempted by a UTEP student is unacceptable and will not be tolerated. All suspected violations of academic integrity at The University of Texas at El Paso must be reported to the [Office of Student Conduct and Conflict Resolution \(OSCCR\)](#) for possible disciplinary action. To learn more, please visit [HOOP: Student Conduct and Discipline](#).

CLASS RECORDINGS

The use of recordings will enable you to have access to class lectures, group discussions, and review sessions in the event you miss a synchronous meeting due to illness or other extenuating circumstance. Our use of such technology is governed by the Federal Educational Rights and Privacy Act (FERPA) and UTEP's acceptable-use policy. A recording of class sessions will be kept and stored by UTEP, in accordance with FERPA and UTEP policies. Your instructor will not share the recordings of your class activities outside of course participants, which include your fellow students, teaching assistants, or graduate assistants, and any guest faculty or community-based learning partners with whom we may engage during a class session. **You may not share recordings outside of this course.** Doing so may result in disciplinary action.

PLAGIARISM DETECTING SOFTWARE

Some of your course work may be submitted to the SafeAssign or MOSS plagiarism detecting software. These tools are used to review submissions for originality and will help you learn how to properly attribute sources.

COPYRIGHT STATEMENT FOR COURSE MATERIALS

All materials used in this course are protected by copyright law. The course materials are only for the use of students currently enrolled in this course and only for the purpose of this course. They may not be further disseminated.

COVID-19 PRECAUTIONS

You must STAY AT HOME and REPORT if you (1) have been diagnosed with COVID-19, (2) are experiencing COVID-19 symptoms, or (3) have had recent contact with a person who has received a positive coronavirus test. Reports should be made at screening.utep.edu. If you know of anyone who should report any of these three criteria, you should encourage them to report. If the individual cannot report, you can report on their behalf by sending an email to COVIDaction@utep.edu.

For each day that you attend campus—for any reason—you must complete the questions on the UTEP screening website (screening.utep.edu) prior to arriving on campus. The website will verify if you are permitted to come to campus. Under no circumstances should anyone come to campus when feeling ill or exhibiting any of the known COVID-19 symptoms. Wear face coverings when in common areas of campus or when others are present.

Course Resources: Where you can go for assistance

UTEP provides a variety of student services and support:

Technology Resources

- [Help Desk](#): Students experiencing technological challenges (email, Blackboard, software, etc.) can submit a ticket to the UTEP Helpdesk for assistance. Contact the Helpdesk via phone, email, chat, website, or in person if on campus.

Academic Resources

- [UTEP Library](#): Access a wide range of resources including online, full-text access to thousands of journals and eBooks plus reference service and librarian assistance for enrolled students.
- [University Writing Center \(UWC\)](#): Submit papers here for assistance with writing style and formatting, ask a tutor for help and explore other writing resources.
- [RefWorks](#): A bibliographic citation tool; check out the RefWorks tutorial and Fact Sheet and Quick-Start Guide.

Individual Resources

- [Military Student Success Center](#): Assists personnel in any branch of service to reach their educational goals.
- [Center for Accommodations and Support Services](#): Assists students with ADA-related accommodations for coursework, housing, and internships.

- [Counseling and Psychological Services](#): Provides a variety of counseling services including individual, couples, and group sessions as well as career and disability assessments.

Weekly Calendar (Subject to Change)

This calendar provides an overview of the course. More details and a weekly checklist are available in the weekly modules on Teams. The due date for assignments is ALWAYS Sunday at 11:59 PM (MST). No late work will be accepted.

	Topic	Readings Due	Assignments Due	Term Projec
Week 1	Introduction to Concurrency and Parallelism	Matloff Chapter 1	Concurrency exercises and discussion	
Week 2	Pthreads	Pthreads tutorial at LLNL	Pthreads exercises and discussion Lab 1 assigned	
Week 3	OpenMP	Matloff Chapter 4 OpenMP tutorial at LLNL	OpenMP exercises and discussion Lab 1 due	
Week 4	Parallel Performance	Matloff Chapter 2	Performance exercises and discussion Lab 2 assigned	
Week 5	Shared Memory Parallelism and Cache Coherence	Matloff Chapter 3	Shared memory exercises and discussion Lab 2 due	
Week 6	GPU Programming	Matloff Chapter 5	GPU programming exercises and discussion Lab 3 assigned	
Week 7	Networks and Message Passing Midterm Exam 1	Matloff Chapter 7	Network and message passing exercises and discussion	
Week 8	Introduction to MPI	Matloff Chapter 8 MPI Tutorial at LLNL	MPI exercises and discussion Lab 3 due	Topics chosen for term project

Week 9	MPI Collective and Asynchronous Communication	Matloff Chapter 8	Collective and asynchronous communication exercises and discussion Lab 4 assigned	Term project planning document due
Week 10	Parallel Matrix Operations	Matloff Chapter 11	Parallel matrix exercises and discussion Lab 4 due	
Week 11	Parallel Data Analysis – MapReduce and Spark	LRU Chapter 2	Map/Reduce and Spark exercises and discussion	Term project planning document due
Week 12	Parallel Data Analysis – Frequent Item Sets Mining, Clustering	LRU Chapter 6, 7.1-7.4	Data analysis exercises and discussion Lab 5 assigned	
Week 13	Parallel Machine Learning Midterm Exam 2	LRU Chapter 12	Parallel machine learning exercises and discussion Lab 5 due	
Week 14	Cloud and Edge Computing			Term project draft reports due
Week 15	Term Project Presentations			
Finals Week	Term Project Presentations			Term project final reports due