

## ECE/ME/EMA/CS 759 – Fall 2023

# High Performance Computing for Applications in Engineering

**Time:** Monday-Wednesday-Friday, 08:25 AM – 09:40 AM  
**Delivery:** Face-to-face: 1800 Engineering Hall  
Online: Zoom synchronous + lecture recordings available in Canvas  
**Instructor:** Dan Negrut  
**Office:** 4150ME  
**Phone:** 608 772 0914  
**E-Mail:** [negrut@wisc.edu](mailto:negrut@wisc.edu)  
**Canvas Course Page:** <https://canvas.wisc.edu/courses/375174>  
**Piazza:** <https://piazza.com/wisc/fall2023/me759001/home>  
**TAs:** Jason Zhou: [zzhou292@wisc.edu](mailto:zzhou292@wisc.edu)  
Huzaifa Unjhwala: [unjhwala@wisc.edu](mailto:unjhwala@wisc.edu)  
Harry Zhang: [h Zhang699@wisc.edu](mailto:h Zhang699@wisc.edu)  
Jingquan Wang: [jwang2373@wisc.edu](mailto:jwang2373@wisc.edu)

### Office Hours:

Monday:	11:00 AM – 12:00 PM	(Dan, in 4150ME)
Monday:	4:30 PM – 6:00 PM	(Huzaifa, in Zoom)
Tuesday:	11:00 AM – 12:00 PM	(Dan, in Zoom)
Tuesday:	2:30 PM – 4:00 PM	(Jingquan, in Zoom)
Tuesday:	4:30 PM – 6:00 PM	(Harry, in Zoom)
Wednesday:	12:00 PM– 1:30 PM	(Harry, in 4150ME)
Wednesday:	2:30 PM– 4:00 PM	(Jason, in Zoom)
Wednesday:	4:30 PM– 6:00 PM	(Huzaifa, in 4150ME)
Thursday:	12:00 PM – 1:30 PM	(Jingquan, in 4150ME)
Thursday:	2:30 PM – 4:00 PM	(Jason, in 4150ME)

**Prerequisites:** ME459. Link to latest deck of ME459 slide is [here](#).

### Recommended Texts:

- R. Bryant and D. O'Hallaron, *Computer Systems: A Programmer's Perspective*, Prentice Hall, 3<sup>rd</sup> Edition, 2015. See [here](#).
- CUDA C++ Programming Guide, version 12.2, see [here](#).
- Peter Pacheco, Matthew Malensek: *An Introduction to Parallel Programming*, Morgan Kaufmann, 2<sup>nd</sup> edition, 2023. See [here](#).
- T. Mattson, et al.: *Patterns for Parallel Programming*, Addison Wesley, 2004. See [here](#).
- Wen-mei W. Hwu, David B. Kirk, Izzat El Hajj: *Programming Massively Parallel Processors: A Hands-on Approach*, Morgan Kaufmann, 2016 ([4<sup>th</sup> edition](#))
- Jason Sanders and Edward Kandrot: *CUDA by Example: An Introduction to General-Purpose GPU Programming*, Addison-Wesley Professional, 2010. See [here](#).

NOTE: Shorter readings will be assigned on a weekly basis. Links to these assigned readings are available in the syllabus, which is available online.

**Course Objectives:** This course seeks to: (a) provide an overview of various advanced computing software and hardware solutions; (b) introduce CUDA for parallel computing on the Graphics Processing Unit (GPU); (c) introduce the OpenMP solution to enabling parallelism across multiple CPU cores; (d) introduce the Message Passing Interface (MPI) standard for leveraging parallelism

on a CPU cluster; and (e) promote an understanding instrumental in deciding what parallel computing model is suitable for which problems. The approach is hands-on, the students are expected to use the lecture information, a series of assignments and a final project to emerge at the end of the class with parallel programming knowledge that can be immediately applied to their projects. The class is designed with students from the College of Engineering in mind, but the material covered might be useful to students from other departments who seek a more applied approach to learning about computing.

**Hardware Used:** The course draws on Euler, a College of Engineering cluster with about 1,000 CPU cores and 90 GPUs. Each student will receive an individual account on Euler that will be used for GPU computing, MPI-enabled parallel computing and possibly OpenMP multi-core computing. You ssh into Euler just like you ssh into any other CAE machine associated with the College of Engineering (CAE is like the DoIT of the College of Engineering). For this to work, you should make sure you have a CAE account. If you don't have one, you can get one by following the instructions [here](#). If during the semester you have difficulties accessing Euler, please post a report of your problem on Piazza and the TAs or instructor will follow up on this issue with CAE.

NOTE: All grading is done on Euler. If you have access at home or work to a laptop/workstation with an NVIDIA GPU card, you could do all the code implementation on that machine and use Euler only to verify that your solution works as expected.

**Course Workload:** The course will have eight quizzes, one comprehensive exam, and one final project.

**Lecturing:** There will be 27 lectures, each 75 minutes long, organized as a Monday-Wednesday-Friday sequence. Owing to this accelerated pace we will have covered the entire course material by November 8, 2023. Relevant issues:

- The lectures will be face to face, in 1800EH
- The lecture slides (as a PPTX file) will be posted online *10-15 min* prior to the beginning of the lecture
  - Access lecture slides in [this folder](#), or via the Canvas class website
- The lectures will be recorded in Zoom and available in Canvas. Recordings will become available approximately 2 hours after the end of the lecture.

**Final Grade Policy:** Grades in ECE/ME/EMA/CS759 will be based on your performance on homework, a series of eight quizzes, one comprehensive final exam, a final project, and course participation. All scores will be available online in Canvas. You will be able to monitor your performance and see aggregate scores. Should you have questions about your score, please contact the instructor. Policies regarding grading and turning in your homework:

1. *Score-related questions must be raised within one week after receiving the score.*
2. *If work that you turned in appears not to have been graded (missing) on the Canvas course website, please point that out to the instructor within one week after the return of the graded work.*
3. *The two assignments with the lowest scores will be dropped when computing the final homework average*

The final grade will be computed using the following weights:

<b>Homework</b>	<b>=</b>	<b>40%</b>
<b>Quizzes</b>	<b>=</b>	<b>5%</b>
<b>Final Exam</b>	<b>=</b>	<b>30%</b>
<b>Final Project</b>	<b>=</b>	<b>20%</b>
<b>Course Participation</b>	<b>=</b>	<b>5%</b>

**Homework:** Assignments will be handed out roughly on a weekly basis and be available on the Canvas website. There will be 10 assignments. Homework solutions should be *neat, well organized, and well commented*. Your score for each assignment will be between 0-100. Your assignments will be managed through **git**. The students can work on the assignment individually, or as part of a team of two students who submit only one assignment. Once on a team, a student can break from the team but not join to form another team. Each student will have to set up and use a private GitLab repo called `repo759` (the name is important) and add the TAs and instructor as repo collaborators (GitLab ids: jwang2373, unjhawala, hzhang699, zzhou292, negrut). You do this here: <https://git.doit.wisc.edu/>.

NOTE: If two students team up, then they will have to inform us that he/she is part of a team. They will do so by each of them including in their repo a text file called *team.txt*, which should list the GitLab IDs of the two team members, one member per line. The GitLab id on the first line of the *team.txt* file will indicate which GitLab repo should be pulled for assignment grading purposes.

NOTE: It is acceptable in this class to use ChatGPT or other online sources of inspiration to complete your assignment. *However*, if you use ChatGPT or other online sources, you should indicate this in your problem answer. Specifically, you should say: “This problem was solved by me 20% and ChatGPT 80%; I prompted ChatGPT for help by asking the following request: write for me a piece of code that does ...”. Or, “This problem was solved by me 20% and 80% was picked up from a Stackoverflow post at this url: blahblahblah.” We will not hold it against you at all if you use internet sources to complete your assignment as long as you give credit where it is due.

Note: Please see “Academic Conduct” rules below to see what sort of assignment solution approach is not acceptable and can have serious consequences.

Please note that:

- Each assignment will be due at 9:00 PM on the Thursday of the week after the assignment was made public. The grader will run a script at 9:01 PM that will pull your assignment solution.
- **Late homework policy:** No late homework will be accepted. In the interest of keeping a level playing field, no exceptions will be made even if your work is late a couple of minutes. Everybody gets the same treatment, no matter how late the homework is submitted – a one minute or 20 minute late homework is equally late and as such won’t be graded.
- You will have two assignments with the lowest scores dropped at the end of the semester.
- Should you need an extension on a assignment due to attending a conference or similar educational event, please contact the instructor no less than two weeks prior to the assignment deadline.

**Final Exam:** There will be one “open-notes” comprehensive exam. The date of the exam is Wednesday, November 15, starting at 7:25 PM and ending at 9:05 PM. This will be in person, most

likely in room 1800EH. This will be a pen and paper exam. The students will *not* have access to the Internet and can only use the slides, notes, etc. they have on their laptop, which should be in “Airplane mode”. The best way to prepare for exam is to participate in class, learn the fundamental concepts, work on the assignments diligently and participate in the Piazza forum discussions. The exam will be scored on a scale of 0 to 100. A review session, which will be recorded through Canvas, will be organized online on Tuesday, November 15, starting at 5:30 PM.

NOTE: There will be no exam during the Final Exams’ week.

**Quizzes:** Eight quizzes will be administered during approximately the last 10 minutes of selected Wednesday lectures throughout the semester. The specific dates for these quizzes are provided in the Syllabus. Each quiz will contain three to five questions that cover the material presented during the three lectures since the previous quiz, as well as previous homework assignments. The quizzes are pen-and-paper and will be conducted under 'closed-book' conditions, meaning no internet access is allowed, and communication with others is prohibited. The questions will be projected on the screen. Students are expected to provide their answers on a standard sheet of paper that you must print out in advance, bring to the lecture, and fill out during the quiz. The quiz template is [here](#). The two quizzes with the lowest scores will be dropped when computing the aggregate quiz score at the end of the semester. Each quiz is worth approximately 0.8% of your final grade, for a total of 5%. Quiz scores will be uploaded to Canvas within one week of each quiz’s administration date.

**Final Project:** The projects are individual or put together by a team of up to two students. You are encouraged to choose a project topic that is related to your research, or something that you are interested in learning more about. A Final Project proposal is due in Canvas no later than 10/30/2023 at 9:00 PM. Once I get a chance to read your Final Project proposal, I will provide feedback and give you the green light (or not) to move on with that project. Feedback will be provided within one week of receiving your proposal so that you can get started as soon as possible.

Your final project should be part of your GitLab private **git** repo. The final project report is due on 12/13/2023, 9 PM. For grading purposes, at 9:01 PM we will pull from your **git** repo the Final Project source files. The PDF report is expected to be dropped on Canvas before 12/13/2023, 9 PM.

**Course Participation:** You will receive 5% of your grade if you demonstrate participation in the Piazza forum discussions. Here are things that matter significantly when it comes to demonstrating participation:

- Provide top-notch answers to a more challenging questions posted on the forum by fellow ME/CS/ECE759 students.
- **[Highly Encouraged]** Follow up on an issue that was left hanging in the lecture. E.g., the instructor didn’t have a good answer for a question posed during lecture or the material was not thorough enough and after the lecture a student would go, read a bit about the open question, and provide a good explanation/answer. This would have to be in the form of two to three PPTX slides that would be emailed to the instructor and also dropped on Piazza
  - o Check with the instructor before going down this path.
- Provide a thoughtful comment on an ME/CS/ECE759 reading assignment. This would have to be in the form of two to three PPTX slides that would be emailed to the instructor and also dropped on Piazza

Notes:

- To judge forum participation, we will use two sources of information:
  - 1) The built-in Piazza activity summary tool, which provides composite information:
    - How many questions you asked

- How many questions you answered
- Time spent on the forum
- 2) At the end of the semester, you will have to upload a document in Canvas that provides five links that you believe showcase the best of your class participation. This will be your “course participation portfolio”. The “class participation portfolio” PDF doc should be uploaded in Canvas no later than 12/13/2023, 9 PM.
- **Your Class Participation score will be 0 if you violate any academic conduct rule, see “Academic Conduct” discussion below**

**Euler Misuse:** Euler, the supercomputer used in this class, is a College of Engineering computing resource and is therefore subject to all rules and regulations of the UW-Madison and UW System. Improper use of Euler can compromise the stability of the entire supercomputer, which is used by tens to hundreds of people, many outside this class, to carry out research or complete assignments. Here’s the policy of CAE, as it was conveyed to us:

“The first two times a student is caught doing something they shouldn't be doing, [CAE] will send them a warning. They won't need to do anything about it other than to stop doing whatever it is CAE saw.

If, for whatever reason, the student continues misusing the supercomputer after two warnings, we will then reach out to their instructor(s) so that they can intervene and teach the student how to use it properly. We will do this up to two times as well. It is at this point that the instructor should determine whether a punitive deterrent is necessary to prevent or correct the problematic behavior.

Finally, if after being notified twice, the instructor fails to remedy the student's behavior, the case will be referred to the CAE director who will consider further action. [...] This is a last resort, but it if the instructor is unable to adequately manage student behavior, the instructor may be barred from using the supercomputer in future courses.”

What constitutes “Euler misuse” will be discussed in the first or second lecture of class. At a very high level:

- a) While on Euler, do not attempt to use `sudo` for any reason, such as when you attempt to install a Linux package. Ask the TA or instructor before considering doing this
- b) **[triggers almost all suspensions on Euler]** Never run a piece of code that **you** compiled or installed/downloaded on the Euler log-in node, i.e., where you land upon ssh-ing into Euler. **Always use slurm to that end, and only do so if the program is not malicious.** It is your responsibility to ensure that the program is not malicious.

Finally, you are strongly encouraged to work on your assignments on your own machine or a CAE workstation. Then, you would only run your assignment at the end on Euler once, to convince yourself that the solution will run on the supercomputer as expected. Note that all the grading of your assignment will take place based on results obtained while running your solution on Euler.

**Letter Grades:** Final letter grades will be based on the total score accumulated on homework and exams throughout the semester using the following straight scale:

Score	Grade
≥92	A
86-92	AB
78-85	B

70-77	BC
60-69	C
50-59	D

**Disability requests:** The University of Wisconsin-Madison supports the right of all enrolled students to a full and equal educational opportunity. The Americans with Disabilities Act (ADA), Wisconsin State Statute (36.12), and UW-Madison policy (Faculty Document 1071) require that students with disabilities be reasonably accommodated in instruction and campus life. Reasonable accommodations for students with disabilities is a shared faculty and student responsibility. Students are expected to inform me of their need for instructional accommodations by the end of the third week of the semester, or as soon as possible after a disability has been incurred or recognized. I will work either directly with you or in coordination with the McBurney Center to identify and provide reasonable instructional accommodations. Disability information, including instructional accommodations as part of a student's educational record, is confidential and protected under FERPA.

**Academic conduct:** There are two sets of rules, pertaining to exam/quizzes and rules related to the assignments.

1) Final Exam and quizzes rules of conduct:

- All your devices (laptop, phones, tablets, etc.) should be set to "Airplane Mode."
- Exams and quizzes are to be completed individually.
- Communication is allowed only with the TAs or the instructor during the exam or quiz.
- Impersonating a colleague or taking an exam on behalf of someone else is prohibited.

2) Assignments will be monitored by automatic cheat checkers such as [Moss](#), including comparing turned-in code to the work of students from the same *and* previous semesters. Students will be asked to explain any suspicious similarities. Thus, sharing your solution with others is not acceptable. If two solutions are identical, this will trigger a flag at our end and will lead to a follow-up discussion with the parties involved.

The penalty for cheating in an assignment is as follows:

- First time:
  - Automatic forfeiting of 5% of the final grade (the component associated with the Course Participation)
  - A grade of zero on the assignment[s] in question, without the possibility to drop the assignment[s]
- Second time:
  - The case will be referred to the Dean of Student Affairs of the College of Engineering

Regarding assignments in this class, the following actions are considered to be "cheating":

- Sharing code: either by copying, retyping, looking at, or supplying a copy of a file from this or a previous semester. Be sure to store your work in protected directories/repos; log off when you leave to prevent others from copying your work without your explicit assistance.
- Coaching: Helping your friend to write a solution, line by line.
  - However, it is fine to explain in words, what you did. In this process, no party sees the other party's code



- Looking at other's code or allowing others to look at yours is cheating. This includes one person looking at code and describing it to another. There is no notion of looking "too much," since no looking is allowed at all.

The following is not considered cheating:

- Using code off the internet or ChatGPT is allowed if you provide a link to the site and explicitly state that you drew on that code; or, for ChatGPT, provide the prompt that you used. You should state the percentage of the solution that is you, and how much is the outside source.
  - This will not affect your score
  - If you don't provide a link to the source of inspiration is considered cheating
- Clarifying with a colleague ambiguities or vague points in class handouts
- It's ok to use line-by-line code provided to you in class.
- Helping others use the computer systems, networks, compilers, debuggers, profilers, or other system facilities.
- Helping others with high-level design issues only as long as student don't show their own code to each other
- Helping others with high-level (not code-based) debugging.
- Reading, for instance, about an algorithm (not the code) to solve an ordering problem.

Keep these things in mind:

- If you share your assignment solution, you cheat as well
- Recall that you can drop two assignments; please do not cheat, simply drop the assignment
- If you are not sure that something you are doing is cheating, don't do it. Rather, send the instructor an email and inquire about the issue at hand

**Dealing with Serious Persistent Personal Issues:** If you have a serious persistent personal issue, such as being hospitalized for an extended period or needing to leave the country for a family matter, please talk to your academic advisor as soon as possible. Such issues consistently affect one's ability to succeed in all classes, rather than just this one, and the academic advisors are equipped to coordinate plans for dealing with them. I will cooperate with such plans, but I cannot construct them independently of the academic advisors.

**UW-Madison Institutional Statement on Diversity** (<https://diversity.wisc.edu>): Diversity is a source of strength, creativity, and innovation for UW-Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals. The University of Wisconsin-Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background - people who as students, faculty, and staff serve Wisconsin and the world.

**Complaints:** If you have a complaint regarding the course and if you are unsatisfied with the response of the instructor, then you should contact the Chair of the Department of Mechanical Engineering. The Chair's office is in 2107ME, and an appointment to see the Chair can be made by contacting the Department Office at 608 263-5372.