APMA 2821: High Performance Computing

Meeting time: Friday, 9-11:30 AM

Instructor: Amanda Howard
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Office Hours: Wednesday, 4-6pm or by appointment

I. Course Description:
High performance computing is behind everything from weather forecasts to efficient airplanes. This is a programming-oriented course about using modern computers to effectively and efficiently solve scientific problems. This course will cover serial and parallel computing using tools such as OpenMP and MPI. It will cover fundamental concepts of parallel computing such as shared and distributed memory models, metrics for performance measuring, and code optimizations including data reuse and memory bandwidth utilization. A final project of the students' choosing will enable them to explore the applications of high performance computing in their field of interest. Each weekly three-hour seminar will be divided between lecture and hands-on programming. Students should be comfortable programming in C++, Fortran, or Python.

II. Course Goals and Outcomes:

Goals: Students will learn to best practices in parallel computing.

Learning Outcomes: After taking this course, students will be able to:

- Compute the theoretical computational limits of a given computer system and compare the performance of existing code to those limits.
- Evaluate a given piece of code to find the limiting factors to its parallelization.
- Write and compile code to solve a scientific computing problem using OpenMP and MPI.

III. Course Materials:
There is no required text.

IV. Course Requirements:
Class participation is essential to your learning. As such, students are expected to attend all course sessions unless they have a prior conflict that has been cleared with me. The programming labs in each course session are considered part of the content for the course, so it is expected that you will stay through the end of the session.

V. Grading Policy/Procedures:
The final grade will be based on bi-weekly homework (60%) and a final project and presentation (40%).

Any code used for your results must be submitted with your homework. The grader must be able to compile and run your code in order to assign you a passing grade. Code must be commented sufficiently to allow the grader to follow your logic.

Each student has two late days that they may use at their discretion. Otherwise, your grade on the assignment will drop 10% for each day late.

Homework should be submitted by email to amanda_howard@brown.edu.

VI. Format, Policies, Procedures, and Expectations of Students:
Class will consist of one weekly seminar. Approximately the first half of the seminar will be a lecture and discussion, and the second half will be an open programming lab. We will meet in the computer lab so you have access to computers. If you prefer to program on your own laptop, please bring the laptop and charger to each class meeting. You are responsible for maintaining your own system if you choose not to use the computer lab computers.

You are encouraged to collaborate and discuss assignments, however any code you submit must be entirely your own.

VII. Special Considerations:
This course assumes you have experience programming in C, C++, or Python. If you have not taken a course in one of these languages, or had significant programming experience outside of a classroom, this course may not be for you. I am happy to meet individually if you have questions about your preparedness.

VIII. Accommodations for Students with Disabilities:
Please inform me if you have a disability or other condition that might require some modification of any of these course procedures. You may speak with me after class or during office hours. For more information, contact Students and Employee Accessibility Services at 401-863-9588 or SEAS@brown.edu.

IX. Inclusivity or Diversity Statement:
This course, along with the Department of Applied Mathematics, believes that a learning community is enriched by diversity, including race, gender, gender identity, sexual identity, age, class and race. I am committed to present materials that are respectful of all dimensions of diversity, and your suggestions and comments are welcomed through email or office hours. Participants who need accommodations, including but not limited to extensions due to religious holidays, should contact me so that we can make arrangements, preferably with as much notice as possible.

X. Academic Honesty:
All Brown University students are expected to adhere to Brown's Academic Code, which reads, in part, 'Academic achievement is evaluated on the basis of work that a student produces independently. A student who obtains credit for work, words, or ideas that are not the products of his or her own effort is dishonest and in violation of Brown's Academic Code. Such dishonesty undermines the integrity of academic standards of the University. Infringement of the Academic Code entails penalties ranging from reprimand to suspension, dismissal, or expulsion from the

University.' Students are expected to familiarize themselves with the Academic Code, in full, located online at: https://www.brown.edu/academics/college/degree/sites/brown.edu.academics.college.degree/files/uploads/Academic-Code.pdf

XI. Tentative Course Schedule:

Week	Topic	Assignments (due Monday at 10am by email unless otherwise noted)
Week 1: Sept 7-11	Introduction to course and differential equations	
Week 2: Sept 14-18	Arithmetic intensity	
Week 3: Sept 21-25	Uses of HPC	Problem set 1 due
Week 4: Sept 28-Oct 2	Theoretical limits of HPC	
Week 5: Oct 5-9	Introduction to OpenMP	Problem set 2 due
Week 6: Oct 12-16	More OpenMP	
Week 7: Oct 19-23	OpenMP programming lab	Problem set 3 due
Week 8: Oct 26-30	Introduction to MPI	
Week 9: Nov 2-6	More MPI	Problem set 4 due
Week 10: Nov 9-13	Even more MPI	Project proposal due
Week 11: Nov 16-20	Final project lab	
Week 12: Nov 23-27 Thanksgiving recess—no class		Problem set 5 due
Week 13: Nov 30-Dec 4	Review	
Week 15: Dec 7-11	Final presentations	Final presentation due
Week 16: Dec 14-18 Exam week—no class		Final report due