

High Performance Computing Syllabus (APM 525/MAE 598), Fall 2022

Faculty Information

Instructor: Prof. Mohamed Moustauoui

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Class Time: T Th: 4:30 pm-5:45 pm

Location: Tempe - ECGG227

Office: WXL847

Office Hours: TTh: 3:00 pm-04:00 pm or by appointment

Personal Zoom link: <https://asu.zoom.us/j/9691850214>

Intended Audience

Beginning graduate students who are considering masters and Ph.D. projects that will require substantial simulation in ordinary and partial differential equations, fluid dynamics, and related areas.

Prerequisites

CSE 205, Object-Oriented Programming and Data Structures or comparable second semester programming course; one semester of linear algebra (MAT 242, 342, 343, or equivalent); and one semester of ordinary differential equations (MAT 274, 275, or equivalent). Some previous exposure to MATLAB, C/C++, Fortran, or other scientific computing language is helpful but not required.

Textbook

Since so much useful material is available online, there are no required textbooks; see Selected Course Resources, below.

Software and course content

Most programs will be run on the Agave cluster, to which you will receive access. More details will be provided in class.

Course Objectives

The exact schedule will depend on our progress, but homework assignments will emphasize parallel algorithms written in compiled languages. You will learn about:

- IEEE floating-point arithmetic
- Efficient use of memory hierarchies
- Arrays and data structures for high-performance computing

- Commonly used compiled languages for scientific software, including Fortran, C and C++
- Notions of parallelism: vectorization, shared-memory multiprocessing with OpenMP; distributed memory multiprocessing with the Message Passing Interface (MPI)

Course Format

The course will be run in a lecture/lab format. Typically, we will have one lecture followed by an in-class computer lab where you can work on related programming exercises with assistance from the instructors and other students. Please bring your laptop to class for the computer lab sessions, which will be announced ahead of time.

Grading Policy

Grades will be based on a combination of programming exercises and related homework (75%) and a final programming project (25%).

Comments on Prerequisites

The expected mathematical background includes calculus, linear algebra, and differential equations sufficient to understand what is meant by a solution of a linear system, a singular linear system, Euler's method and the Runge-Kutta methods.

The expected programming background is a minimum of a one-year sequence in some procedural programming language, such as C/C++, Fortran, MATLAB, etc. Some familiarity with Fortran and C/C++ is helpful but not required. We will cover the basics of Fortran, C, and C++ in class, but you should be familiar with basic concepts like subroutines, looping, dummy arguments, etc.

We will cover some of main tools of the Unix operating system and shells in class. Some familiarity with Unix or the command-line interface of Windows operating systems is helpful but not required.

Face coverings are recommended at ASU locations

Face covering are recommended while in ASU buildings.

Syllabus Disclaimer

All items on this syllabus are subject to change. Any in-class announcement, verbal or written, is considered an official addendum to this syllabus.

Academic Integrity

Academic honesty is expected of all students in all examinations, papers, and laboratory work, academic transactions and records. The possible sanctions include, but are not limited to, appropriate grade penalties, course failure (indicated on the transcript as a grade of E), course failure due to academic dishonesty (indicated on the transcript as a grade of XE), loss of registration privileges, disqualification and dismissal. For more information, see <http://provost.asu.edu/academicintegrity>

Disability Resources

Students who feel they will need disability accommodations in this class but have not registered with the Disability Resource Center (DRC) should contact DRC immediately. The DRC Tempe office is located on the first floor of the Matthews Center Building. DRC staff can also be reached at: (480) 965-1234 (V) or (480) 965-9000 (TTY). For additional information, visit: www.asu.edu/studentaffairs/ed/drc.

Expected Classroom Behavior - Campus Courses

Arrive on time for class. Excessive tardiness will be subject to sanctions. Under no circumstances should you allow your cell phone to ring during class. Any disruptive behavior, which includes ringing cell phones, listening to your mp3/iPod player, text messaging, constant talking, eating food noisily, reading a newspaper will not be tolerated. The use of laptops (unless for note taking), cell phones, MP3, IPOD, etc. are strictly prohibited during class. The use of recording devices is prohibited.

Policy Against Threatening Behavior

All incidents and allegations of violent or threatening conduct by an ASU student (whether on-or off campus) must be reported to the ASU Police Department (ASU PD) and the Office of the Dean of Students. If either office determines that the behavior poses or has posed a serious threat to personal safety or to the welfare of the campus, the student will not be permitted to return to campus or reside in any ASU residence hall until an appropriate threat assessment has been completed and, if necessary, conditions for return are imposed. ASU PD, the Office of the Dean of Students, and other appropriate offices will coordinate the assessment in light of the relevant circumstances. For more information please visit <https://eoss.asu.edu/dos/srr/PoliciesAndProcedures> and <https://eoss.asu.edu/dos/safety/ThreateningBehavior>.

Reporting Title IX Violations

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at <https://sexualviolenceprevention.asu.edu/faqs>.

Policy on Sexual Discrimination

Arizona State University is committed to providing an environment free of discrimination, harassment, or retaliation for the entire university community, including all students, faculty members, staff employees, and guests. ASU expressly prohibits [discrimination](#), [harassment](#), and [retaliation](#) by employees, students, contractors, or agents of the university based on any protected status: race, color, religion, sex, national origin, age, disability, veteran status, sexual orientation, gender identity, and genetic information.

As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU

Counseling Services, <https://eoss.asu.edu/counseling>, is available if you wish discuss any concerns confidentially and privately.

Copyrighted Materials

Students must refrain from uploading to any course shell, discussion board, or website used by the course instructor or other course forum, material that is not the student's original work, unless the students first comply with all applicable copyright laws; faculty members reserve the right to delete materials on the grounds of suspected copyright infringement. The content of this course, including lectures and other instructional materials, are copyrighted materials. Students may not share outside the class, including uploading, selling or distributing course content or notes taken during the conduct of the course. Any recording of class sessions is authorized only for the use of students enrolled in this course during their enrollment in this course. Records and excerpts of recordings may not be distributed to others. Any (parts of) exams, assignment, reports, or solutions to these, from current or previous semester, posted to any website not affiliated with ASU will result in academic integrity disciplinary actions against the students posting them and the students using them.

Selected Course Resources

References on floating-point arithmetic

- David Goldberg, "What Every Computer Scientist Should Know about Floating-Point Arithmetic," ACM Comput. Surv. 23 (1991), 5–48.
- Michael L. Overton, Numerical Computing with IEEE Floating Point Arithmetic. Philadelphia: Society for Industrial and Applied Mathematics, 2001.
- J.-M. Muller, N. Brisebarre, F. de Dinechnin, et al., Handbook of Floating-Point Arithmetic, Boston: Birkhäuser, 2010.

Shells and scripting languages

- E. Quigley, Unix Shells by Example, 4th ed. New York: Prentice-Hall, 2005.
- R. L. Schwartz, B. D. Foy, and T. Phoenix, Learning Perl, 6th ed. Sebastopol, CA: O'Reilly Media, Inc., 2011.

References on parallel programming

- C. Breshears, The Art of Concurrency. Sebastopol, CA: O'Reilly Media, Inc., 2009.
- B. Chapman, G. Jost, and R. van der Pas, Using OpenMP. Cambridge, MA: The MIT Press, 2008.
- W. Gropp, E. Lusk, and A. Skjue, Using MPI: Portable Parallel Programming with the Message- Passing Interface, 2nd ed. Cambridge, MA: The MIT Press, 1999.
- M. Snir, S. Otto, S. Huss-Lederman, D. Walker, and J. Dongarra, MPI: The Complete Reference, Vols. 1 and 2. Cambridge, MA: The MIT Press, 1998.

References on the Fortran language

- W. S. Brainerd, Guide to Fortran 2008 Programming. London: Springer-Verlag, 2015.
- I. Chivers and J. Sleightholme, Introduction to Programming with Fortran, 3rd ed. London: Springer- Verlag, 2015.
- M. Metcalf, J. Reid, and M. Cohen, Modern Fortran Explained, 4th ed. Oxford: Oxford University Press, 2011; corrected printing, 2013.
- J. C. Adamas, W. S. Brainerd, et al., The Fortran 2003 Handbook: The Complete Syntax, Features, and Procedures. London: Springer-Verlag, 2009.

References on the C language

- B. W. Kernighan and D. M. Ritchie, The C Programming Language, 2nd ed. Englewood Cliffs, NJ: Prentice Hall, 1988.
- P. J. Plauger, The Standard C Library. Englewood Cliffs, NJ: Prentice Hall, 1992.

References on the C++ language

- B. Stroustrup, Programming: Principles and Practice Using C++, 2nd ed. Reading, MA: Addison-Wesley, 2014.
- B. Stroustrup, The C++ Programming Language, 4th ed. Reading, MA: Addison-Wesley, 2013.
- S. Meyers, Effective C++, 3rd ed. Boston: Pearson Education, Inc., 2008.
- S. Meyers, Effective Modern C++. Sebastopol, CA: O'Reilly Media, 2014.
- S. Meyers, Effective STL. Boston: Pearson Education, Inc., 2008.