



CS 677: Parallel Programming for Many-core Processors
School of Engineering and Science
Spring 2021

Meeting Times: Wednesday 6:30-9:00 PM
Classroom Location: Zoom
Instructor: Philippos Mordohai
Contact Info: Home (until further notice), Philippos.Mordohai@stevens.edu
Office Hours: Mondays 5:00-6:00 PM and by appointment
Course Web Address: https://mordohai.github.io/classes/cs677_s21.html
Prerequisite(s): CS 537 or CS 511 or CS 631
Corequisite(s): N/A
Cross-listed with: N/A

COURSE DESCRIPTION

The objective of the course is to provide the students with knowledge of the state-of-the art hardware architectures and programming philosophies for gaming, machine learning, scientific computation, simulation, and visualization. The emphasis will be on the NVIDIA's CUDA, which currently is the most widely used parallel computing architecture.

STUDENT LEARNING OUTCOMES

After successful completion of this course, students will be able to...

- Memory Types - Select the appropriate memory types for a multicore application to minimize latency.
- Divergence - Identify and describe divergence in SIMD/SIMT programs.
- Resources - Design algorithms taking into account system resources such as memory, register availability, and maximum number of cores/active threads.
- Occupancy - Estimate the occupancy of the multicore architecture and identify bottlenecks. (MS -GDSP C expertise)

COURSE FORMAT AND STRUCTURE

This course is comprised of weekly three-hour lectures.

COURSE MATERIALS

Textbook(s): Programming Massively Parallel Processors: A Hands-on Approach by David Kirk and Wen-mei Hwu, Morgan Kaufmann, 2016 (3rd edition)
Other Readings: Available on course web page
Materials: None

COURSE REQUIREMENTS

- Attendance** Attendance is not mandatory, but there will be regular quizzes during the semester.
- Participation** Participation is strongly encouraged.
- Homework** There will be four homework assignments, which will be tentatively assigned in Weeks 2, 4, 6 and 7 and will be due one week later.
- Quizzes** There will be ten quizzes during the semester, at the beginning of each lecture.
- Project** Each student will select a project, which has to be approved by me regarding relevance and feasibility. I will also provide suggestions for potential projects and pointers to relevant material. Students actively involved in research can select a project related to their research, but new work has to be done during the semester. Large projects can be performed by groups of two students. In **Week 9**, each student will briefly present a proposal of his or her project, **which will have to be approved by Week 8**. Project status updates will be given three weeks later and the final presentations will be given in the last week of classes. The written reports will be due on the date of the (non-existent) final exam.

GRADING PROCEDURES

Grades will be based on:

- Homework (40%)
- Quizzes (20%)
- Final Project (40%, including proposal and progress report which count for 5% each)

Late Policy

No late submissions will be allowed without consent from the instructor. If urgent or unusual circumstances prevent you from submitting a homework assignment in time, please e-mail me explaining the situation.

TENTATIVE COURSE SCHEDULE

Week Starting	Topic(s)	Readings	Assignment
February 3	Introduction to massively parallel programming and CUDA	Kirk & Hwu Ch. 1, 2 and 3	
February 10	CUDA threads and atomics; CUDA memories	Kirk & Hwu Ch. 4 and 5	Homework 1
February 17	Performance considerations	Kirk & Hwu Ch. 5	
February 24	More performance considerations; reduction trees; parallel patterns: prefix sum	Kirk & Hwu Ch. 5 and 8	Homework 2
March 3	Project ideas; Convolution, constant memory and cache	Kirk & Hwu Ch. 7	
March 10	Case study: MRI reconstruction; Timers	Kirk & Hwu Ch. 14	Homework 3
March 17	Case study: Electrostatic Potential Calculation; Binning	Kirk & Hwu Ch. 15, 17, 10 and notes	Homework 4

March 24	Computational thinking	Kirk & Hwu Ch. 17	
March 31	Pinned Memory; Streams; Thurst	Kirk & Hwu Ch. 13 and notes	
April 7	Parallel Sorting; Sparse matrix and vector operations; Summed area tables	Notes	
April 14	Bitonic sorting; More libraries; OpenCL	Kirk & Hwu Ch. 14 and notes	Project status reports (due 4/18)
April 21	Project status reports; More OpenCL; OpenACC; OpenMP	Notes	
April 28	Deep learning; Latest GPU and CUDA features	Notes	
May 5	Project Presentations		
May 12			Final Project report due on projected day of final exam

ACADEMIC INTEGRITY

Graduate Student Code of Academic Integrity

All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline.

All graduate students are bound by the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at www.stevens.edu/provost/graduate-academics.

EXAM ROOM CONDITIONS

There are no exams scheduled in this course. Quizzes are considered open-book. No collaboration with anyone else is allowed.

LEARNING ACCOMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

For more information about Disability Services and the process to receive accommodations, visit <https://www.stevens.edu/office-disability-services> (Links to an external site.). If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone 201-216-3748.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

INCLUSIVITY

Name and Pronoun Usage

As this course includes group work and in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

Inclusion Statement

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements.

You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.

MENTAL HEALTH RESOURCES

Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression). Appointments are strongly encouraged and can be made by phone (201-216-5177) or in-person (on the 7th floor of the Howe Center). CAPS is open from 9:00 am – 5:00 pm Mondays, Wednesdays, Thursdays and Fridays and from 9:00 am – 7:00 pm on Tuesdays during the Fall and Spring semesters.

EMERGENCY INFORMATION

In the event of an urgent or emergent concern about the safety of yourself or someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or on their emergency line at 201-216-3911. These phone lines are staffed 24/7, year round. Other 24/7 resources

for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text “Home” to 741-741). If you are concerned about the wellbeing of another Stevens student, and the matter is not urgent or time sensitive, please email the CARE Team at care@stevens.edu. A member of the CARE Team will respond to your concern as soon as possible.