

CS 677: Parallel Programming for Many-core Processors

School of Engineering and Science Spring 2019

Meeting Times:	Wednesday 6:30-9:00 PM
Classroom Location:	Carnegie 315
Instructor:	Philippos Mordohai
Contact Info:	North 209 (until further notice), Philippos.Mordohai@stevens.edu, 201 216 5611
Office Hours:	Tuesday 5:00-6:00 PM and by appointment
Course Web Address:	https://mordohai.github.io/classes/cs677_s20.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.

LEARNING OBJECTIVES

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)

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 3, 4, 6 and 7 and will be due one week later.			
Quizzes	There will be several 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. Each student will			
	briefly present a proposal of his or her project, which will have to be approved			
	by Week 8, in Week 9. Longer 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.			
Exams	The midterm is scheduled for Week 8.			

GRADING PROCEDURES

Grades will	be	based	on:
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Homework	(40%)
Quizzes	(10%)
Final Project	(35%)
Midterm Exam	(15%)

TENTATIVE COURSE SCHEDULE

Week Starting	Topic(s)	Readings	Assignment
January 20	Introduction to massively parallel programming and CUDA	Kirk & Hwu Ch. 1, 2 and 3	
January 27	CUDA threads and atomics; CUDA memories	Kirk & Hwu Ch. 4 and 5	
February 3	Performance considerations	Kirk & Hwu Ch. 5	Homework 1
February 10	More performance considerations; reduction trees; parallel patterns: prefix sum	Kirk & Hwu Ch. 5 and 8	Homework 2
February 17	Project ideas; Case study: MRI reconstruction	Kirk & Hwu Ch. 14	
February 24	Convolution, constant memory and cache	Kirk & Hwu Ch. 7	Homework 3
March 2	Case study: electrostatic potential calculation; input binning; sparse matrix and	Kirk & Hwu Ch. 15, 17, 10 and notes	Homework 4

	vector operations; summed area tables		
March 9	Midterm Exam		Project Proposals
March 23	Computational thinking	Kirk & Hwu Ch. 17	
March 30	Pinned Memory; streams; Thurst	Kirk & Hwu Ch. 13 and notes	
April 6	More libraries; OpenCL	Kirk & Hwu Ch. 14 and notes	Project status reports (due 4/17)
April 13	More OpenCL.	Notes	
April 20	Latest GPU and CUDA features; OpenACC, OpenMP	Notes	
April 27	Project Presentations		
May 11			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.

Special Provisions for Undergraduate Students in 500-level Courses

The general provisions of the Stevens Honor System do not apply fully to graduate courses, 500 level or otherwise. Any student who wishes to report an undergraduate for a violation in a 500-level course shall submit the report to the Honor Board following the protocol for undergraduate courses, and an investigation will be conducted following the same process for an appeal on false accusation described in Section 8.04 of the Bylaws of the Honor System. Any student who wishes to report a graduate student may submit the report to the Dean of Graduate Academics or to the Honor Board, who will refer the report to the Dean. The Honor Board Chairman will give the Dean of Graduate Academics weekly updates on the progress of any casework relating to 500-level courses. For more information about the scope, penalties, and procedures pertaining to undergraduate students in 500-level courses, see Section 9 of the Bylaws of the Honor System document, located on the Honor Board website.

EXAM ROOM CONDITIONS

The following procedures apply to quizzes and exams for this course. As the instructor, I reserve the right to modify any conditions set forth below by printing revised Exam Room Conditions on the quiz or exam.

1. Students may use the following devices during quizzes and exams. Any electronic devices that are not mentioned in the list below are <u>not</u> permitted.

Dovico	Permitted?		
Device	Yes	No	
Laptops		Х	
Cell Phones		Х	
Tablets		Х	
Smart Watches		Х	
Google Glass		Х	
Other		Х	

2. Students may use the following materials during quizzes, marked with Q, and exams, marked with E. Any materials that are not mentioned in the list below are <u>not</u> permitted.

Matorial		Permitted?	
	Yes	No	
Handwritten Notes		FO	
Conditions:		ĽŲ	
Typed Notes		FO	
Conditions:		ĽŲ	
Textbooks		БО	
Conditions:		EQ	
Readings		FO	
Conditions:		ĽŲ	
Other (specify)			

3. Students are not allowed to work with or talk to other students during quizzes and exams.

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.

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.

For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/office-disability-services. 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.

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.