ME 964 – High Performance Computing for Engineering Applications
Fall 2008

Time: 9:30 – 10:45 Tu&Th
Location: 2106ME

Instructor: Dan Negrut
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Course Page: http://sbel.wisc.edu/Courses/ME964/2008/index.htm
Grades Page: http://learnuw.wisc.edu

T.A.: N/A
Grader: Nicholas Schafer (npschafer@wisc.edu)

Office Hours:
Monday, 2 – 4:30 PM
Wednesday, 2 – 4:30 PM
Other times by appointment (please call or email to arrange)

Prerequisites: C Programming or Data Structures classes

Recommended Texts (there is no required text):
NVIDIA, *NVIDIA CUDA Programming Guide V2.0*, 2008, download from NVIDIA website
H. Nguyen (ed.), *GPU Gems 3*, Addison Wesley, 2007 (on reserve at Wendt)
M. Pharr (ed.), *GPU Gems 2*, Addison Wesley, 2005 (on reserve at Wendt)
T. Mattson, et al. *Patterns for Parallel Programming*, Addison Wesley, 2005 (on reserve at Wendt)

Course Objectives: The course is meant to (a) expose the students to existing High-Performance Computing software and hardware, (b) present basic software design patterns for high performance parallel computing, and (c) introduce HPC on the GPU, as an affordable and effective way for reaching Teraflop computation speed for applications in Science and Engineering.

Course Setup: The course is built around NVIDIA's software (CUDA programming model) and hardware (GeForce 8800 GT) solutions for high performance parallel computing. Upon completion of the course the students should emerge with specific GPU programming knowledge that can be applied in any area of scientific computation.

Course Workload: A set of homeworks that require GPU programming will be assigned. The course will have one midterm exam, one midterm project, and one final project. The last three to four weeks of the class will be entirely dedicated to work related to the final project. The students will have the option to work on actual code they use in their research and will rely on GPU programming for speeding up critical components of the code. All projects will be individual projects.

ME 964 - Introduction to Dynamic Systems
Fall 2008

For this class, the Microsoft PowerPoint notes used in class will be posted online at http://sbel.wisc.edu/Courses/ME964/2008/index.htm. I will also attempt to record the lectures and post the MP3 files online at http://sbel.wisc.edu/Courses/ME964/2008/audio.htm. Since I have not done this before I will stick with this for as long as possible. I plan on making mp3 available for three reasons: (a) the person grading your assignments is telecommuting from Copenhagen, Denmark and needs to stay abreast of ME964 events; (b) in case you miss class you will have the opportunity to go back and listen to the lecture; (c) this is the first time I'm teaching the class and I want to have a chance to review my performance. The mp3 will be available at http://sbel.wisc.edu/Courses/ME964/2008/index.htm.
Grades in ME964 will be based on your performance on homework, midterm exam, one midterm project, one final project, and course participation. All homework and exam scores will be maintained on the Learn@UW course website. This will allow you to monitor your performance and see aggregate scores for the rest of the class, which can give you a continuous idea of your performance in relation to the rest of the class. Should you have questions about your score, please contact me. Policies regarding grading and turning in your homework:

1. *Score-related questions about homeworks, midterm exam, and midterm project must be raised prior to the next class period after receiving the score.*
2. *If homework that you turned in appears not to be graded (missing) on the Learn@UW course website please point that out to me within one week after the return of the corresponding set of graded homeworks. It is a good practice to save your homework so that I will be able to update the grade to give you full credit for your work.*
3. *The homework with the lowest score will be dropped when computing the final homework average*

Percentage participation to the final grade shall be distributed in the following manner:

Homework	**=**	**30%**
Midterm Exam	**=**	**10%**
Midterm Project	**=**	**20%**
Final Project	**=**	**35%**
Course Participation	**=**	**5%**

Homework: Assignments will be handed out on a weekly basis for the first 9 weeks of class. There will be no assigned homework afterwards. The homework solution is expected to be emailed to the address me964uw@gmail.com no later than the midnight of the day when it is due. Homework solutions should be *neat, well organized, and well commented*. Your score for each assignment will be between 0-100. You can turn in two late homeworks. In order to turn in a late homework, send an email to me964uw@gmail.com with a subject line that reads "YourFirstName YourLastName: Late HW Notice". The email should be sent prior to the due date of the homework in question. Scores for homework that is overdue by more than three days will be penalized by 10 points for each additional day. Saturdays, Sundays, and official university holidays don't account as overdue days.

Midterm Exam: There will be one midterm exam that will cover material introduced in the first part of the course. There will be no need for a computer for this test. The best way to prepare for exams is to

participate in class, learn the fundamental concepts, and work on the assignments diligently. The exam will be scored on a scale of 1 to 100. Note that there will be no final exam.

Midterm Project: There will be one midterm project assigned after the eight week of class. For all purposes, the midterm project will be like a more challenging assignment. You will have three weeks to work on the midterm project. All students are expected to work on the project individually. The problem assigned for this project will be the same. An intermediate report will be due one week after the date the project is assigned and it will outline your design decisions vis-à-vis the parallel algorithm you are going to implement.

Final Project: There will be one final project. The projects will be individual and the students will choose a project topic after consulting with the instructor. Ideally, the topic of the project is related to your research. Alternatively, the instructor will provide a list of projects you can choose from. It is anticipated that you will have about four weeks to work on the final project. No homework will be assigned during this time. Each student will make a presentation, about ten minutes long, regarding his/her final project during at the time/date of the final exam (December 14, 2008). An intermediate report is due two weeks after the final project is assigned. The final project is due on the last day of the exam week, at 11:59 PM.

Course Participation: You are expected to participate actively in class discussions and to pose questions. Beyond this and in order to earn the 5% assigned to this category you will have to do two things. First, you will have to post at least five answers to questions posted on the NVIDIA CUDA forum (http://forums.nvidia.com/index.php?s=e5afc4f2eddd37f6e8a6a2e19900e56c&showforum=62). In order to post on this forum you will have to register as a CUDA user. To this end, please use the following id when registering with the NVIDIA Forum: *??me964uw*. Replace the first two characters with the initials of your first and last name, upper case. Second, you will have to post at least five answers by the end of the semesters to the questions posted on the ME964 bulletin board (http://sbel.wisc.edu/Forum/index.php?board=3.0).

Disability requests: I must hear from anyone who has a disability that may require some modification of seating, testing or other class requirements so that appropriate arrangements may be made. Please see me after class or during my office hours.

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 3650ME, and an appointment to see the Chair can be made by contacting the Department Office at 608 263-5372.

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

Score	**Grade**
≥92	A
86-91	AB
78-85	B
70-77	BC
60-69	C
50-59	D

ME 964 High Performance Computing for Engineering Applications

Fall 2008 – **Tentative** Syllabus

Date	Title	Lecturer	HW Assigned	Observations
09/02	Syllabus related issues Overview of C language	Negrut		
09/04	Overview of C language	Negrut	HW1 (due 09/11)	HW: C programming-related
09/09	High Performance Computing: Why, and why now?	Negrut		
09/11	GPU Computing and CUDA Intro	Negrut	HW2 (due 09/18)	HW: CUDA Profiler, device emulation, Hello World.
09/16	GPU Computing and CUDA Intro	Negrut		
09/18	CUDA Memory Model	Negrut	HW3 (due 09/25)	HW: Matrix addition
09/23	GPU Compute Core	Negrut		
09/25	GPU Compute Core	Negrut	HW4 (due 10/02)	HW: Tile Matrix Multiplication Simple vector reduction Kernel Call Overhead
09/30	CUDA Memory Space (Registers, Constant, Global)	Negrut		
10/02	CUDA Memory Space (Shared Memory, Bank Conflicts) CUDA Occupancy Calculator, Resource Utilization	Negrut	HW5 (due 10/09)	HW: Matrix 2D convolution
10/07	Guest Lecture	Michael Garland, NVIDIA		
10/09	Control Flow in CUDA	Negrut	HW6 (due 10/18)	HW: Parallel Scan
10/14	Parallel Programming – Application Performance	Negrut		
10/16	Parallel Programming – Algorithm Styles	Negrut		
10/21	Parallel Programming – Algorithm Styles. Collision Detection Presentation	Negrut	Midterm Project Assigned (due 11/18)	The same project is assigned to entire class
10/23	Guest Lecture: GPGPU and Graphics HW: A Brief History	Mikola Lysenko		
10/28	Guest Lecture	Mark Hill, ECE, UW		Topic: TBA
10/30	Guest Lecture	Karu Sankaralingam, CS, UW		Topic: TBA
11/04	Guest Lecture: N-body Problem	David Dynerman, Grad. Student, Math UW		Talk about how to compute the interaction forces in a system of N mutually interaction bodies (long range electrostatic interaction present).
11/06	Midterm Project: Design Outline AND Final Project:	Each Student		Choose your topic. Each student presents his project topic: why this topic, and outline of context in which

	Topic Presentation		topic is relevant
11/11	Guest Lecture: MPI	Darius Buntinas, Argonne National Lab	PLEASE NOTE: This lecture will run till 11:30 AM Room TBA
11/13	Guest Lecture: MPI	Darius Buntinas, Argonne National Lab	PLEASE NOTE: This lecture will run till 11:30 AM. Room TBA
11/18	Midterm Project: Individual Presentation	Each Student	
11/20	MIDTERM EXAM		
11/25	Guest Lecture: Multicore Parallel Programming with TBB	Arch Robinson, INTEL	
11/27	**NO CLASS**		THANKSGIVING HOLIDAY
12/02	No Class		No lecture due to the longer MPI lectures on 11/13 and 11/15
12/04	No Class		No lecture due to the TBB double header on 11/25
12/09	Parallel Collision Detection with CUDA, revisited	Negrut	
12/11	Feedback, Course Evaluation	Negrut	

Final Exam: 2:45 P.M. SUN. DEC 14, Room 2106