

ECE/ME/EMA/CS 759: High Performance Computing for Engineering Applications

Fall 2023 – Tentative Syllabus

Date	Title	HW Assigned Quiz dates	Recommended Reading. Other Observations
09/06 [L01]	Syllabus related issues. Course overview.		Linux Command Line basics .
09/08 [L02]	From Code to Machine Instructions. The FDX Cycle. Instruction Level Parallelism.	HW01 out (due 09/14): C programming related	Clone this GitHub repo and read the FAQ and Slurm scripts therein. Read & re-read the C material covered in ME459 . Read about Euler and “module” .
09/11 [L03]	Superscalar architectures. Measuring Computer Performance. Memory Aspects		Read gdb tutorial in ME459 . Read Chapter 5 of Brian W. Kernighan and Dennis M. Ritchie “The C Programming Language” book .
09/13 [L04]	The memory hierarchy. Caches.	In-class quiz – 1.	Build Management & CMake in ME459 (p.387 & on).
09/15 [L05]	Caches, wrap up. Virtual Memory	HW02 out (due 09/21): C programming related	Read the git material covered in ME459 (p.484 & on). Read how to produce a good commit comment .
09/18 [L06]	The Walls to Sequential Computing. Moore’s Law. Parallel Computing. Flynn’s Taxonomy. Amdahl’s Law.		Read the Amdahl article. Good & short writeup on Virtual Memory. Nice article about somewhat mitigating Power Wall
09/20 [L07]	GPU Computing Intro. The CUDA Programming Model. CUDA Execution Configuration	In-class quiz – 2.	Knuth paper on premature optimization .
09/22 [L08]	GPU Memory Spaces	HW03 out (due 09/28): GPU/CUDA related	Read Lighterra article .
09/25 [L09]	GPU Scheduling Issues. Execution Divergence. Control Flow in CUDA.		Read ACM article about C++ compiler optimizations
09/27	NO CLASS	DAN OUT OF TOWN	Read about the Latest Tesla Architecture
09/29 [L10]	CUDA Shared Memory Issues.	HW04 out (due 10/05): GPU/CUDA related	Skim through CUDA Programming Guide .
10/02 [L11]	CUDA Shared Memory Issues Global Memory Access Patterns and Implications.		GPU computing evolution article of Nickolls & Dally
10/04 [L12]	Global Memory Access Patterns and Implications. Data hazard in parallel computing	In-class quiz – 3.	Intro discussion on Unified Memory in CUDA
10/06 [L13]	Atomic operations in CUDA. GPU code optimization rules of thumb CUDA Case Studies: a) Vector Reduction in CUDA.	HW05 out (due 10/12): GPU/CUDA related.	Maximizing Unified Memory Performance in CUDA
10/09 [L14]	CUDA Case Studies b) Parallel Prefix Scan on the GPU. c) 1D Stencil Operation.		White paper on NVIDIA’s Grace Hopper . Skim through GPU Tech Conference (GTC) talk titles . [use “Search” feature & keywords]. 1990 paper on prefix scan. A 2017 paper on prefix scan.
10/11 [L15]	Streams, and overlapping data copy with execution.	In-class quiz – 4.	Detailed micro-benchmarking study , for Volta. CUDA C Best Practices Guide . CUDA Warp-Level primitives .
10/13	GPU Computing: Advanced Features.	HW06 out (due 10/19):	GTC 2022 talk on CUDA.

[L16]	Debugging & Profiling execution on the GPU	GPU/CUDA related.	
10/16	GPU Computing with thrust and cub		Paper on thrust in GPU Gems 4, by Nathan Bell and Jared Hoberock.
[L17]			
10/18	GPU Tensor Core Aspects	In-class quiz – 5.	Material on doing GPU computing via Python
[L18]			
10/20	Hardware aspects relevant in multi-core, shared memory parallel computing	HW07 out (due 10/26): thrust/cub related	Document on unified memory, a chronological take
[L19]			
10/23	Multi-core Parallel Computing with OpenMP. Parallel Regions		GTC talk about multi-GPU computing.
[L20]			
10/25	OpenMP Work Sharing	In-class quiz – 6.	Workshop material on node performance optimization (Supercomputing 2019)
[L21]	Scoping aspects in OpenMP		
			Workshop material OpenMP 5.0 and advanced host performance (Supercomputing 2019)
10/27	OpenMP synchronization	HW08 out (due 11/02): OpenMP related	Workshop material on OpenMP tasks (Supercomputing 2019)
[L22]	[OpenMP NUMA Aspects – supplemental] Performance issues, OpenMP related		
10/30	Critical Thinking. Code Optimization Aspects		Final Project Proposal due 9 PM
[L23]			
11/01	Computing with Supercomputers.	In-class quiz – 7.	Chapter 12, from Agner Fog's optimization tutorial
[L24]			
11/03	MPI Parallel Programming	HW09 out (due 11/09): OpenMP related	2005 article of Dongarra et al. for an overview of HPC
[L25]	General Introduction, Point-to-Point Communication		
11/06	MPI Parallel Programming		Workshop material, advanced MPI programming (Supercomputing 2019)
[L26]	Point-to-Point communication: Blocking vs. Non-blocking sends		[advanced]
11/08	MPI Parallel Programming: MPI Collectives	In-class quiz – 8.	
[L27]	Overview of topics covered in the class		
11/10	NO CLASS	HW10 out (due 11/20 - 9 PM): OpenMP/MPI related	
11/13	NO CLASS		
11/15	EVENING EXAM	Review @ 7:30 PM, on **TUESDAY** Exam @ 7:25 – 9:05 PM. Room: Biochem 1120 (even last digit) Microb Sc. 1520 (otherwise)	NOTE: Review will be online, via Zoom. It will be recorded. Exam is face-to-face.
11/17	NO CLASS		
11/20	NO CLASS		
11/22	NO CLASS		
11/24	NO CLASS		
11/27	NO CLASS		
11/29	NO CLASS		
12/01	NO CLASS		
12/04	NO CLASS		
12/06	NO CLASS		
12/08	NO CLASS		
12/11	NO CLASS		
12/13	NO CLASS	Final Project Due @ 9 PM Portfolio for “Class Participation” Due @ 9PM	

Comprehensive Exam: November 15, at 7:25 – 9:05 PM
(Review Session: November 14, at 7 pm – online, will be recorded)

Final Project due date: 12/13/2022, 9 PM
(submitted via GitLab)