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

Spring 2021 – Syllabus

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| --- | --- | --- | --- | --- | --- |
| Date | Title | HW Assigned | Recommended Reading. Other Observations | | |
| 01/25 [L01] | Syllabus related issues.  Course overview. |  | Linux [command line](https://www.lynda.com/Linux-tutorials/Welcome/435539/482226-4.html) online tutorial. Read Slurm as covered in [ME459](https://uwmadison.box.com/s/943jyv29y4u145uajfedgxamhn4ru9qx) (pp. 95-97) | | |
| 01/27 [L02] | From Code to Machine Instructions. The FDX Cycle. Instruction Level Parallelism. | HW01 (due 02/05):  C programming related | Read & re-read the C material covered in [ME459](https://uwmadison.box.com/s/943jyv29y4u145uajfedgxamhn4ru9qx) (p.114 & on). Read about [Euler and “module”](https://uwmadison.box.com/s/eu45vz9uc1a913i831b1saiu554ueb4z). | | |
| 01/29 [L03] | Superscalar architectures. Measuring Computer Performance. Memory Aspects |  | Read gdb tutorial in [ME459](https://uwmadison.box.com/s/943jyv29y4u145uajfedgxamhn4ru9qx) (p.649 & on). Read Chapter 5 of Brian W. Kernighan and Dennis M. Ritchie “The C Programming Language” [book](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiQ8Y279PzVAhVm5oMKHSdyCZIQFggoMAA&url=https%3A%2F%2Fgithub.com%2Fgermanoa%2Fcompiladores%2Fblob%2Fmaster%2Fdoc%2Febook%2FThe%2520C%2520Programming%2520Language%2520-%25202nd%2520Edition%2520-%2520Ritchie%2520Kernighan.pdf&usg=AFQjCNERIxO0pE6fAXzSnZV7Y32JTDKQ5A). | | |
| 02/01 [L04] | The memory hierarchy. Caches. |  | Build Management & CMake in [ME459](https://uwmadison.box.com/s/943jyv29y4u145uajfedgxamhn4ru9qx) (p.354 & on). | | |
| 02/03 [L05] | Caches, wrap up. Virtual Memory | HW02 (due 02/11):  C programming related | Read the git material covered in [ME459](https://uwmadison.box.com/s/943jyv29y4u145uajfedgxamhn4ru9qx) (p.449 & on). Read how to produce a [good commit comment](https://chris.beams.io/posts/git-commit/). | | |
| 02/05 [L06] | The Walls to Sequential Computing. Moore’s Law. |  | Read the [Amdahl](https://uwmadison.box.com/s/z21zx63u3n3swxk23luex6mv0n9az96a) article. | | |
| 02/08 [L07] | Parallel Computing. Flynn’s Taxonomy. Amdahl’s Law. |  | [Knuth paper on premature optimization.](https://uwmadison.box.com/s/40oh4cw2j0tlouf6ip6fqv2guegrn6rz) | | |
| 02/10 [L08] | GPU Computing Intro. The CUDA Programming Model. CUDA Execution Configuration | HW03 (due 02/18):  GPU/CUDA related | Read Lighterra [article](http://www.lighterra.com/papers/modernmicroprocessors/). | | |
| 02/12 [L09] | GPU Memory Spaces |  | Read [ACM article](https://queue.acm.org/detail.cfm?id=3372264) about C++ compiler optimizations | | |
| 02/15 [L10] | GPU Scheduling Issues |  | Read about the [Latest Tesla Architecture](https://uwmadison.box.com/s/c3j9jiy6feq31qh4nuuli9ce40xebvlb) | | |
| 02/17  [L11] | Execution Divergence. Control Flow in CUDA. Global Memory Access Patterns and Implications. | HW04 (due 02/25):  GPU/CUDA related | Skim through [CUDA Programming Guide](https://docs.nvidia.com/pdf/CUDA_C_Programming_Guide.pdf). | | |
| 02/19 [L12] | CUDA Shared Memory Issues.  Atomic operations in CUDA. |  | GPU computing evolution [article](https://uwmadison.box.com/s/o63jve7gq6kn9f473btedx2k4tp33m34) of Nickolls & Dally | | |
| 02/22 [L13] | Using the CUDA profiler.  Example: 1D Stencil Operation. |  | [Intro discussion on Unified Memory in CUDA](http://www.drdobbs.com/parallel/unified-memory-in-cuda-6-a-brief-overvie/240169095) | | |
| 02/24 [L14] | Tiling as a Programing Pattern in CUDA  Example: Vector Reduction in CUDA | HW05 (due 03/04):  GPU/CUDA related. | [Maximizing Unified Memory Performance in CUDA](https://devblogs.nvidia.com/maximizing-unified-memory-performance-cuda/) | | |
| 02/26 [L15] | CUDA Optimization Issues. Resource Utilization Issues.  Parallel Prefix Scan on the GPU.  Using Multiple Streams in CUDA. |  | Skim through GPU Tech Conference (GTC) talk [titles](http://on-demand-gtc.gputechconf.com/gtcnew/on-demand-gtc.php).  [use “Search” feature & keywords] | | |
| 03/01 [L16] | Streams, and overlapping data copy with execution. |  | Detailed micro-benchmarking [study](https://uwmadison.box.com/s/qdmt5f9qxpnbx431t2oo7neh6a7ri6zs), for Volta. [CUDA C Best Practices Guide](http://docs.nvidia.com/cuda/pdf/CUDA_C_Best_Practices_Guide.pdf). | | |
| 03/03 [L17] | GPU Computing: Advanced Features. | HW06 (due 03/11):  GPU/CUDA related. | Watch GTC 2018 [talk](javascript:pop_window('http://on-demand.gputechconf.com/gtc/2018/video/S8430/')) about Unified Memory | | |
| 03/05 [L18] | GPU Computing with thrust and cub |  | [Paper](https://uwmadison.box.com/s/5gdq2gaqf15xjl1cd550ttsko782fbaz) on thrust in GPU Gems 4, by Nathan Bell and Jared Hoberock. | | |
| 03/08 [L19] | Hardware aspects relevant in multi-core, shared memory parallel computing |  | [Document](https://sbel.wisc.edu/wp-content/uploads/sites/569/2018/05/TR-2014-09.pdf) on unified memory, a chronological take | | |
| 03/10 [L20] | Multi-core Parallel Computing with OpenMP. Parallel Regions | HW07 (due 03/18):  thrust/cub related | [Cache coherence on Power 9 – Volta systems w/ NVLINK2](http://on-demand.gputechconf.com/gtc/2018/video/S8172/)  [advanced] | | |
| 03/12 [L21] | OpenMP Work Sharing |  | | | Workshop material on [node performance optimization](https://uwmadison.box.com/s/cvva3ybaq0867e160hqf6l92yp9gbthx)  (Supercomputing 2019) |
| 03/15  [L22] | OpenMP Work Sharing |  | | Workshop material [OpenMP 5.0 and advanced host performance](https://uwmadison.box.com/s/dftxq7z83u6bc1e33lbihhcuvb5ek2uc) (Supercomputing 2019) | |
| 03/17 [L23] | OpenMP NUMA Aspects. Caching and OpenMP | HW08 (due 03/25):  OpenMP related | Workshop material on [OpenMP tasks](https://uwmadison.box.com/s/40yxdvu41prgvfuzvv668lhx78eafos0) (Supercomputing 2019) | | |
| 03/19  [L24] | Critical Thinking. Code Optimization Aspects |  | | Chapter 12, from Agner Fog's optimization [tutorial](https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwju75C19_zVAhWp7IMKHUkrBd0QFggoMAA&url=http%3A%2F%2Fwww.agner.org%2Foptimize%2Foptimizing_cpp.pdf&usg=AFQjCNGP0nMMAIT_TFVmh4NvK43_Ef-dOw) | |
| 03/22 [L25] | Computing with Supercomputers. |  | | **Final Project Proposal due at 9 PM** | |
| 03/24 [L26] | MPI Parallel Programming General Introduction, Point-to-Point Communication | HW09 (due 04/01):  OpenMP related | | 2005 article of Dongarra et al. for an [overview of HPC](https://uwmadison.box.com/s/fi2h0s0d4rgvviepc1dd92m9jqoemq86) | |
| 03/26 [L27] | MPI Parallel Programming  Point-to-Point communication:  Blocking vs. Non-blocking sends |  | | Workshop material, advanced [MPI programming](https://uwmadison.box.com/s/ymhcrw7xc49u3cvs86jeva9bnek99sfe) (Supercomputing 2019) [advanced] | |
| 03/29 [L28] | MPI Parallel Programming: MPI Collectives |  | |  | |
| 03/31 | NO CLASS | HW10 (due 04/08):  OpenMP/MPI related | |  | |
| 04/02 | NO CLASS |  | |  | |
| 04/05 | NO CLASS |  | |  | |
| 04/07 | NO CLASS |  | |  | |
| 04/09 | NO CLASS |  | |  | |
| 04/12 | NO CLASS | Final Exam Review. Starting at 7 PM | |  | |
| 04/14 | NO CLASS |  | |  | |
| 04/16 | NO CLASS |  | |  | |
| 04/19 | NO CLASS |  | |  | |
| 04/21 | NO CLASS |  | |  | |
| 04/23 | NO CLASS |  | |  | |
| 04/26 | NO CLASS |  | |  | |
| 04/28 | NO CLASS |  | |  | |
| 04/30 | NO CLASS | OFFICIAL END OF SPRING SEMSTER | |  | |

**Final Project due date: 05/07/2021, 10:05 AM**  
**(submitted via git)**

**Comprehensive Exam: April 13, at 7:00 PM**  
**(Review Session: April 12, at 7 pm – online, in Canvas, will be recorded)**