

**Bennett University**

**Course Details:**

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| **Course Name:** | **High Performance Computing** | **Course Code:** | | | **ECSE602L** | |
| **Department :** | **Computer Science Engineering** | **Type:** | | | **Core** | |
| **L-T-P Structure** | **3-0-2** | **Credits** | **4** | **Pre-requisite:** | **Programming Language, Data Structures** | |
| **Course Objectives** | The goal of this course is to give solid foundations for developing, analysing and implementing parallel, scalable and locality-efficient algorithms. It covers main ideas for three major classes of machines: Work-span models, network models, and deep memory hierarchies. | | | | | |
| **Course Outcome** | **At the end of the course, the students will be able to:**   1. Design appropriate searching and sorting techniques for high-performance systems. 2. Analyze the algorithmic design for Work-span models, network models, and deep memory hierarchies. 3. Develop the algorithms and techniques on parallel and distributed systems. | | | | | |
| **Course Contents:** | **Topics** | | | | | **No. of Hours** |
|  | Intro to High Performance Computing, Intro to Work-Span Model, The Multithreaded DAG Model, Brent's Theorem | | | | | 3 |
|  | Work Optimality and Weak Scaling, Basic Concurrency Primitives, Data Races and Race Conditions | | | | | 3 |
|  | Introduction and Tutorial of OpenMP with relevant examples | | | | | 3 |
|  | Comparison based sorting: Comparator networks, Bitonic Sequences, Bitonic Splits, Bitonic Merge, Bitonic Sort | | | | | 3 |
|  | Scans and List Ranking, Prefix Sums, Parallel Scans, Segmented Scans, Linked list as array pools, Tree Computations, Parallel Independent Sets | | | | | 3 |
|  | Euler Tour Technique, Shared Memory Parallel BFS, High Level Approach to Parallel BFS, Bag splitting | | | | | 3 |
|  | Intro to Dist Memory Models: A Basic Model of Distributed Memory, Point to Point Completion Semantics, Vector Reductions | | | | | 3 |
|  | Intro to MPI, Intro to Network Models Links and Diameter, Mappings and Congestion, Exploiting Higher Dimensions, Dist Dense Matrix Multiply, A geometric view, Applying Loomis Whitney | | | | | 3 |
|  | Efficiency and 1D algorithm, A 2D Algorithm and its efficiency, Dist. Memory Sorting, Distributed Bitonic Merge via binary exchange, Bitonic merge via transposes, Linear time distributed sort | | | | | 3 |
|  | Distributed BFS, Graphs and adjacency Matrices, Matrix based BFS, 1D distributed BFS, Graph partitioning, Graph bisection and planar separators | | | | | 3 |
|  | Kernighan Lin Algorithm, Graph Coarsening, Computing a maximal matching, Spectral partitioning | | | | | 3 |
|  | Basic Model of locality: Two level memories, Minimum transfers to sort, Matrix vector multiply, Algorithmic Time, Energy and Power, Speed Limits, Time Limits, Power Limits, The Dynamic power equation, Power Knobs | | | | | 3 |
|  | Exploiting DVFS, Algorithmic Dynamic power, Parallelism and DVFS, I/O Avoiding algorithms, External Memory Mergesort, Two-way external memory Merging, Multiway Merging | | | | | 3 |
|  | Cache oblivious algorithms, the ideal cache model, LRU replacement, Proof of LRU OPT Competitiveness, The Tall-cache assumption, Cache oblivious matrix multiplication, cache oblivious binary search | | | | | 3 |
| **Text Book:** | 1. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar. [*Introduction to Parallel Computing*](https://www.cs.purdue.edu/homes/ayg/book/Slides/). Addison-Wesley, 2003 | | | | | |
| **References:** | 1. Grama et. al., Introduction to Parallel Computing 2. Georg Hager, Gerhard Wellein. Introduction to High Performance Computing for Scientists and Engineers. CRC Press. Taylor and Francis Group | | | | | |
| **Special Interventions** | Plagiarism Checker for Assignment by Stanford and Bennett  Google Form for Quiz  Piazza for Q&A  POLLEV for Online Polling | | | | | |