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| **Savitribai Phule Pune University**  **Fourth Year of Computer Engineering (2015 Course) 410241: High Performance Computing** | | | | |
| **Teaching Scheme: TH: 04 Hours/Week** | | **Credit 04** | **Examination Scheme: In-Sem (Paper): 30 Marks**  **End-Sem (Paper): 70 Marks** | |
| **Prerequisite Courses:** 210253-Microprocessor, 210244- Computer Organization and Architecture, 210254-Principles of Programming Languages, 310251- Systems Programming and  Operating System | | | | |
| **Companion Course:** 410246-Laboratory Practice I | | | | |
| **Course Objectives:**   * To study parallel computing hardware and programming models * To be conversant with performance analysis and modeling of parallel programs * To understand the options available to parallelize the programs * To know the operating system requirements to qualify in handling the parallelization | | | | |
| **Course Outcomes:**  On completion of the course, student will be able to–   * Describe different parallel architectures, inter-connect networks, programming models * Develop an efficient parallel algorithm to solve given problem * Analyze and measure performance of modern parallel computing systems * Build the logic to parallelize the programming task | | | | |
| **Course Contents** | | | | |
| **Unit I** | **Introduction** | | | **09 Hours** |
| Motivating Parallelism, Scope of Parallel Computing, Parallel Programming Platforms: Implicit Parallelism, Trends in Microprocessor and Architectures, Limitations of Memory, System Performance, Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines, Scalable design principles, Architectures: N-wide superscalar architectures, Multi-core  architecture. | | | | |
| **Unit II** | **Parallel Programming** | | | **09 Hours** |
| Principles of Parallel Algorithm Design: Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models, The Age of Parallel Processing, the Rise of  GPU Computing, A Brief History of GPUs, Early GPU. | | | | |
| **Unit III** | **Basic Communication** | | | **09 Hours** |

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| Operations- One-to-All Broadcast and All-to-One Reduction, All-to-All Broadcast and Reduction, All-Reduce and Prefix-Sum Operations, Scatter and Gather, All-to-All Personalized Communication, Circular Shift, Improving the Speed of Some Communication  Operations. | | |
| **Unit IV** | **Analytical Models of Parallel Programs** | **09 Hours** |
| Analytical Models: Sources of overhead in Parallel Programs, Performance Metrics for Parallel Systems, and The effect of Granularity on Performance, Scalability of Parallel Systems, Minimum execution time and minimum cost, optimal execution time. Dense Matrix Algorithms: Matrix-  Vector Multiplication, Matrix-Matrix Multiplication. | | |
| **Unit V** | **Parallel Algorithms- Sorting and Graph** | **09 Hours** |
| Issues in Sorting on Parallel Computers, Bubble Sort and its Variants, Parallelizing Quick sort, All-Pairs Shortest Paths, Algorithm for sparse graph, Parallel Depth-First Search, Parallel Best-  First Search. | | |
| **Unit VI** | **CUDA Architecture** | **09 Hours** |
| CUDA Architecture, Using the CUDA Architecture, Applications of CUDA Introduction to CUDA C-Write and launch CUDA C kernels, Manage GPU memory, Manage  communication and synchronization, Parallel programming in CUDA- C. | | |
| **Books:** | | |
| **Text:**   1. Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, "Introduction to Parallel Computing", 2nd edition, Addison-Wesley, 2003, ISBN: 0-201-64865-2 2. Jason sanders, Edward Kandrot, “CUDA by Example”, Addison-Wesley, ISBN-13: 978-0-   13-138768-3 | | |
| **References:**   1. Kai Hwang, ”Scalable Parallel Computing”, McGraw Hill 1998, ISBN:0070317984 2. Shane Cook, “CUDA Programming: A Developer's Guide to Parallel Computing with GPUs”, Morgan Kaufmann Publishers Inc. San Francisco, CA, USA 2013 ISBN: 9780124159884 3. David Culler Jaswinder Pal Singh, ”Parallel Computer Architecture: A Hardware/Software Approach”, Morgan Kaufmann,1999, ISBN 978-1-55860-343-1 4. Rod Stephens, “ Essential Algorithms”, Wiley, ISBN: 978-1-118-61210-1 | | |