Course Code	Course Title	L	T	P	C
BCSE412L	Parallel Computing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To introduce the fundamentals of parallel computing architectures and paradigms.
2. To understand the technologies, system architecture, and communication architecture that has driven the growth of parallel computing systems.
3. To develop and execute basic parallel applications using programming models and tools.

Course Outcomes

Students who complete this course successfully are expected to:

1. Comprehend the hardware and software organization of parallel computing systems.
2. Design and implement Parallel algorithms.
3. Experiment with mechanisms such as client/server and P2P algorithms, remote procedure calls (RPC/RMI).
4. Analyse the requirements for programming parallel systems and critically evaluate the strengths and weaknesses of parallel programming models.
5. Analyse the efficiency of a parallel processing system and evaluate the types of application for which parallel programming is useful.

Module:1	Parallelism Fundamentals	4 hours

Motivation – Key Concepts and Challenges – Overview of Parallel computing – Flynn's Taxonomy – Multi-Core Processors – Shared vs Distributed memory.

Module:2	Parallel Architectures	7hours

Introduction - SIMD – Vector Processing – GPUs, TPUs– Instruction Level Support for Parallel Programming - Introduction to Open MP Programming.

Module:3	Parallel Algorithm Design	8 hours

Decomposition Techniques – Characteristics of Tasks and Interactions – Mapping Techniques for Load balancing – Methods for Containing Interaction Over heads - Parallel Algorithm Models – Design concepts: Threading for Functionality, Threading for Performance, Turnaround ,Throughput , Decomposing the work, Task Decomposition, Data Decomposition; Correctness concepts: Race Conditions, Critical Region, Mutual Exclusion, Synchronization, Barrier Synchronization , Deadlock; Performance concepts: Speedup, Efficiency, Granularity, Load Balance;

Module:4	Communication Operations	7 hours

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.

Module:5	Analytical Modeling	5 hours

Sources of Overhead in Parallel Programs - Performance Metrics for Parallel Systems - Effect of Granularity and Data Mapping on Performance - Scalability of Parallel Systems - Minimum Execution Time and Minimum Cost-Optimal Execution

Time –Analysis of PRAM - Asymptotic Analysis of Parallel Programs - Other Scalability Metrics.		
Module:6	**Parallel Programming**	**7 hours**
Shared Memory Programming - Distributed Memory Programming– Distributed Shared Memory – Message Passing – Programming Using the Message Passing Paradigm – Group Communication – Heterogeneous computing systems – Case Study (RPC and Java RMI).		
Module:7	**Parallel Algorithms**	**5hours**
Matrix Multiplication - Sorting Algorithms - Graph Algorithms – Applications		
Module:8	**Recent Trends**	**2 hours**
Guest lectures from Industry and, Research and Development Organizations		
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Ananth Grama, Anshul Gupta, George Karypis and Vipin Kumar, "Introduction to Parallel Computing", Pearson, 2nd Edition, 2015.
2.	David Kirk, Wen-mei W. Hwu, Programming Massively Parallel Processors - A Hands-on Approach, Morgan Kaufmann, 3rd Edition, 2016.
Reference Books	
1.	Michael J. Quinn, Parallel Computing: Theory and Practice, 2nd edition, McGraw Hill Education, India, 2017.
2.	Ian Foster , Gerhard R. Joubert, Ludek Kucera, Wolfgang E. Nagel, Frans Peters, Parallel Computing: Technology Trends: Advances in Parallel Computing, IOS Press,2020.

Mode of Evaluation: CAT / written assignment / Quiz / FAT			
Recommended by Board of Studies	12-05-2023		
Approved by Academic Council	No. 70	Date	24-06-2023