INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

PARALLEL AND DISTRIBUTED COMPUTING								
V Semester: CSE (CS)								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
ACCD07	**Elective**	3	0	0	3	40	60	100
Contact Classes: 48	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 48**		
Prerequisites: Computer Architecture and Operating Systems								

I. COURSE OVERVIEW:

This course introduces the basics of parallel and distributed computing, focusing on how to build fast and efficient programs. Students will learn about processes, multitasking, threads, and memory management. Key topics include shared and distributed memory programming using tools like MPI and Pthreads.The course also explores advanced computing techniques using OpenCL and CUDA for graphical processing. Students will study how distributed systems work, including communication, synchronization, and handling issues like deadlock. With a mix of theory and hands-on programming, this course prepares students to design and optimize modern parallel and distributed systems for real-world applications.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The basics of parallel computing, including processes, threads, and memory models.
II. The concepts of distributed memory programming using MPI for communication and performance optimization.
III. GPU-based parallel computing using OpenCL and CUDA for developing advanced applications.
IV. The fundamental aspects of distributed systems, including communication, synchronization, and deadlock handling.

III. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO1 Understand the fundamentals of parallel computing, including concurrency, multitasking, and memory models.
CO2 Apply distributed memory programming concepts using MPI for communication, I/O, and performance optimization in parallel systems.
CO3 Apply shared memory programming using Pthreads for thread synchronization, critical sections, and thread safety.
CO4 Develop GPU-based parallel programs using OpenCL and CUDA for computationally intensive applications.
CO5 Analyze distributed systems, focusing on communication models, logical time, and synchronization techniques.
CO6 Evaluate and design solutions for distributed mutual exclusion and deadlock detection using advanced algorithms.

IV. COURSE CONTENT:

MODULE-I: INTRODUCTION TO PARALLEL COMPUTING (10)

Motivation for parallel programming Need Concurrency in computing Basics of processes, multitasking, and threads cache mappings caches and programs virtual memory Instruction level parallelism hardware multi-threading Parallel Hardware-SI,MD MIMD Interconnection networks cache coherence Issues in shared memory model and distributed memory model Parallel Software-Caveats- coordinating processes/ threads- hybrid model shared memory model and distributed memory model - I/O performance of parallel programs- parallel program design

MODULE-II: DISTRIBUTED AND SHARED MEMORY (10)

DISTRIBUTED MEMORY PROGRAMMING WITH MPI: Basic MPI programming MPI_Init and MPI. Finalize MPI communicators SPMD programs MPI_Send and MPI_Recv message matching MPI- I/O parallel I/O collective communication, Tree-structured communication - MPI_Reduce MPI_Allreduce, broadcast, scatter, gather, all gather MPI derived types dynamic process management performance evaluation of MPI programs- A Parallel Sorting Algorithm

SHARED MEMORY PARADIGM WITH PTHREADS: Basics of threads, Pthreads thread synchronization critical sections busy waiting mutex semaphores barriers and condition variables read write locks with examples - Caches, cache coherence, and false sharing Thread safety-Pthreads case study.

MODULE-III: HYBRID SOFT COMPUTING TECHNIQUES&APPLICATIONS (10)

GRAPHICAL PROCESSING PARADIGMS: OPENCL AND INTRODUCTION TO CUDA 9

Introduction to OpenCL Example-OpenCL Platforms- Devices-Contexts - OpenCL programming Built-In Functions-Programs Object and Kernel Object Memory Objects - Buffers and Images Introduction to CUDA programming.

MODULE-IV: A MODEL OF DISTRIBUTED COMPUTATIONS (09)

Definition, Relation to computer system components, Motivation, Relation to parallel systems, Message passing systems versus shared memory systems, Primitives for distributed communication, Synchronous versus asynchronous executions, Design issues and challenges.

A model of distributed computations: A distributed program, A model of distributed executions, Models of communication networks, Global state, Cuts, Past and future cones of an event, Models of process communications. Logical Time: A framework for a system of logical clocks, Scalar time, Vector time, and Physical clock synchronization: NTP.

MODULE-V: DISTRIBUTED MUTEX & DEADLOCK (09)

Distributed Mutex& Deadlock: Distributed mutual exclusion algorithms: Introduction, Preliminaries, Lamport‘s algorithm, Ricart-Agrawala algorithm, Maekawa‘s algorithm, Suzuki–Kasami‘s broadcast algorithm.

Deadlock detection in distributed systems: Introduction, System model, Preliminaries, Models of deadlocks, Knapp‘s classification, Algorithms for the single resource model, the AND model, and the OR model.

V. TEXT BOOKS:

1. P. Pacheco, An Introduction to Parallel Programming, Morgan Kaufmann, 1st Edition., 2011.
2. B. Wilkinson and M. Allen, Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers, Pearson, 2nd Edition., 2005.

VI. REFERENCE BOOKS:

1. M. J. Quinn, Parallel Programming in C with MPI and OpenMP, McGraw-Hill, 1st Edition., 2004.
2. D. B. Kirk and W. W. Hwu, Programming Massively Parallel Processors: A Hands-on

Approach, Morgan Kaufmann, 3rd Edition., 2016.
3. G. Coulouris, J. Dollimore, T. Kindberg, and G. Blair, Distributed Systems*: Concepts and Design*, Pearson, 5th Edition., 2011.

VII. ELECTRONIC REFERENCES:

1. https://onlinecourses.nptel.ac.in/noc21_cs15/preview
2. https://www.distributedsystemscourse.com/

VIII. MATERIALS ONLINE

1. Course template
2. Tutorial question bank
3. Tech-talk topics
4. Open-ended experiments
5. Definitions and terminology
6. Assignments
7. Model question paper – I
8. Model question paper – II
9. Lecture notes
10. PowerPoint presentation
11. E-Learning Readiness Videos (ELRV)