CS6306 PARALLEL PROGRAMMING	L	T	P	EL	CREDITS
	3	0	4	3	6

Prerequisites for the course: NONE

OBJECTIVES:

- To identify the scope available for parallel programming over different models
- To identify the challenges in parallel programming
- To develop parallel programs using OpenMP in shared memory
- To develop parallel programs in distributed memory using MPI
- To program heterogeneous processors using CUDA and OPENCL

MODULE I :	L	T	P	EL
	3	0	0	3

Introduction to Parallel Computing –Need for Parallel Computing – Concurrent, Parallel and Distributed Systems – The Von Neumann Architecture – Flynn's Taxonomy

SUGGESTED ACTIVITIES :

- EL – Fundamentals of Parallel Computing.
- In Class activity for Conversion of Simple Serial Problem to Parallel Problem

SUGGESTED EVALUATION METHODS:

- Assignment problems
- Quizzes

MODULE II :	L	T	P	EL
	3	0	4	3

Parallel Computing Models - ILP, TLP and Data Parallelism – Parallel Programming Overview: Processes, Tasks and Threads - Parallel Programming Models: Shared Memory Programming – Distributed Programming.

SUGGESTED ACTIVITIES :

- Flipped classroom and activity
- EL - Basics of Inter Process Communication (IPC)
- Practical - Programs on Interprocess Communication (Shared memory, Message Queue, Pipes)

SUGGESTED EVALUATION METHODS:

- Assignment problems
- Quizzes

MODULE III :	L	T	P	EL
	3	0	0	3

Interconnection Networks : Shared Memory Interconnects - Distributed Memory Interconnects – Parallel Software – Identifying Potential Parallelism – Techniques for Parallelizing Programs

SUGGESTED ACTIVITIES :

- EL – Basics of Interconnection Networks
- In class activity to identify techniques for parallelizing the program

SUGGESTED EVALUATION METHODS:

- Assignment problems
- Quizzes

MODULE IV :	L	T	P	EL
	3	0	4	3

Performance: Speedup and Efficiency – Amdahl's Law – Scalability – Parallel Program Design – Writing and Running Parallel Programs.

SUGGESTED ACTIVITIES :

- EL- Writing simple parallel programs
- In class activity for speed and efficiency calculation
- Practical - Analyzing and comparing the speedups on serial and parallel programs

SUGGESTED EVALUATION METHODS:

- Assignment problems
- Quizzes

MODULE V :	L	T	P	EL
	3	0	0	3

Challenges of Parallel Programming: Cache Coherence Issues - Memory Consistency Models – Maintaining Memory Consistency – Synchronization Issues.

SUGGESTED ACTIVITIES :

- Flipped Class room
- EL – Basics of cache principles

SUGGESTED EVALUATION METHODS:

- Assignment problems
- Quizzes

MODULE VI:	L	T	P	EL
	6	0	8	3

Shared Memory Model: OpenMP Execution Model – Parallel regions – Work Sharing – Data Environment – Synchronization – Reductions – Data Parallelism – Functional Parallelism – Runtime Library Routines– Environment Variables–Performance Improvements.

SUGGESTED ACTIVITIES :

- EL – Introduction to OpenMP
- Practical - Programs on OpenMP and Applications on OpenMP

SUGGESTED EVALUATION METHODS:

- Assignment problems
- Quizzes

MODULE VII:	L	T	P	EL
	3	0	4	3
The MPI Programming Model – MPI Basics – Circuit Satisfiability – Global Operations – Collective Operations.				
SUGGESTED ACTIVITIES : • EL – Introduction to MPI • Practical - Programs on MPI				
SUGGESTED EVALUATION METHODS: • Assignment problems • Quizzes				

MODULE VIII:	L	T	P	EL
	3	0	4	3
Other MPI Features – Asynchronous Communication – Performance Issues – Combining OpenMP and MPI.				
SUGGESTED ACTIVITIES : • Combinations of in Class & Flipped class rooms • EL – Applications of OpenMP and MPI • Practical - Applications on MPI				
SUGGESTED EVALUATION METHODS: • Assignment problems • Quizzes				

MODULE IX:	L	T	P	EL
	3	0	4	3
GPU Architecture – Basics of CUDA – CUDA Threads – CUDA Memories – Synchronization Handling – - Performance Issues - Application Development using CUDA.				
SUGGESTED ACTIVITIES : • Flipped classroom • EL – Basics of GPU and Applications of CUDA • Practical - Programs on CUDA				
SUGGESTED EVALUATION METHODS: • Assignment problems • Quizzes				

MODULE X:	L	T	P	EL
	3	0	4	3
Introduction to OpenCL – Benefits of OpenCL- Anatomy of OpenCL – OpenCL Architecture – Application development using OpenCL				
SUGGESTED ACTIVITIES : • Mostly in Class • EL – Applications of OpenCL. • Practical - Programs on OpenCL.				

SUGGESTED EVALUATION METHODS:

- Assignment problems
- Tutorial problems

OUTCOMES:

Upon completion of the course, the students will be able to:

- Point out the fundamental concepts of parallelism
- Discuss the challenges in parallel programming
- Parallelize a serial program and point out the advantages and overheads
- Implement parallel programs with OpenMP and MPI
- Develop parallel programs in a heterogeneous processor using OpenCL and CUDA

TEXT BOOKS

1. Peter S. Pacheco, "An Introduction to Parallel Programming", Morgan Kaufmann, 2011.
2. Michael J Quinn, "Parallel Programming in C with MPI and OpenMP", Tata McGraw Hill, 2003.
3. David B. Kirk and Wen-mei W. Hwu, "Programming Massively Parallel Processors", Morgan Kaufmann, 2010.

REFERENCES:

1. Ananth Grama, George Karypis, Vipin Kumar and Anshul Gupta, "Introduction to Parallel Computing", Second Edition, Pearson Education Limited, 2003.
2. John L. Hennessy and David A. Patterson, "Computer Architecture – A Quantitative Approach", Morgan Kaufmann / Elsevier Publishers, 5th. Edition, 2012.
3. Ian Foster, "Designing and Building Parallel Programs: Concepts and Tools for Parallel Software Engineering", Addison Wesley Longman Publishing Co., USA, 1995.
4. David E. Culler, Jaswinder Pal Singh, Anoop Gupta, "Parallel Computing Architecture: A Hardware/Software Approach" , Morgan Kaufmann / Elsevier Publishers, 1999.
5. OpenMP Programmer's Manual.
6. MPI Programmer's Manual
7. "Introduction to OpenCL Programming", AMD, 2010.

EVALUATION PATTERN:

Category of Course	Continuous Assessment	Mid – Semester Assessment	End Semester
Theory Integrated with Practical	**15(T) + 25 (P)**	**20**	**40**

CO - PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓			✓						✓
CO2	✓	✓	✓	✓		✓				✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓			✓	✓		✓
CO4	✓	✓	✓	✓	✓				✓	✓		✓
CO5	✓	✓	✓	✓	✓				✓	✓		✓