

## SEMESTER S7

### HIGH PERFORMANCE COMPUTING

(Common to CS/CR/CM/CD/CA/AM/AD)

<b>Course Code</b>	<b>PECST757</b>	<b>CIE Marks</b>	40
<b>Teaching Hours/Week (L: T:P: R)</b>	3:0:0:0	<b>ESE Marks</b>	60
<b>Credits</b>	3	<b>Exam Hours</b>	2 Hrs. 30 Min.
<b>Prerequisites (if any)</b>	None	<b>Course Type</b>	Theory

#### Course Objectives:

1. To Gain an understanding of the modern processor architectures.
2. To Give an introduction to parallel programming using OpenMP and MPI.

### SYLLABUS

<b>Module No.</b>	<b>Syllabus Description</b>	<b>Contact Hours</b>
<b>1</b>	<b>Modern processors:</b> Stored-program computer architecture- <i>General-purpose cache-based microprocessor architecture</i> - Performance metrics and benchmarks -Moore's Law - Pipelining - Super scalarity - SIMD - <i>Memory hierarchies</i> - Cache , Cache mapping, Prefetch, Multicore processors - Multithreaded processors - <i>Vector processors</i> - Design principles - Maximum performance estimates - Programming for vector architectures.	<b>9</b>
<b>2</b>	<b>Parallel computers</b> - Taxonomy of parallel computing paradigms - <i>Shared-memory computers</i> - Cache coherence - UMA, ccNUMA, Distributed-memory computers - Hierarchical (hybrid) systems - <i>Networks</i> - Basic performance characteristics of networks, Buses, Switched and fat-tree networks - Mesh networks - Hybrids.	<b>9</b>
<b>3</b>	<b>Shared-memory parallel programming with OpenMP:-</b> <i>Short introduction to OpenMP</i> - Parallel execution - Data scoping - OpenMP worksharing for loops - Synchronization, Reductions, Loop scheduling, Tasking,Miscellaneous, Case study: OpenMP-parallel Jacobi algorithm	<b>9</b>

<b>4</b>	<b>Distributed-memory parallel programming with MPI:-</b> Message passing - <i>A short introduction to MPI</i> , A simple example, Messages and point-to-point communication, Collective communication, Nonblocking point-to-point communication, Virtual topologies. <i>Example-MPI parallelization of a Jacobi solver</i> - MPI implementation - Performance properties.	<b>9</b>
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**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
<b>5</b>	<b>15</b>	<b>10</b>	<b>10</b>	<b>40</b>

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

Part A	Part B	Total
<ul style="list-style-type: none"> <li>● 2 Questions from each module.</li> <li>● Total of 8 Questions, each carrying 3 marks</li> </ul> <p><b>(8x3 =24 marks)</b></p>	<ul style="list-style-type: none"> <li>● Each question carries 9 marks.</li> <li>● Two questions will be given from each module, out of which 1 question should be answered.</li> <li>● Each question can have a maximum of 3 subdivisions.</li> </ul> <p style="text-align: center;"><b>(4x9 = 36 marks)</b></p>	<b>60</b>

**Course Outcomes (COs)**

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
<b>CO1</b>	Describe parallel computing architectures supported by modern processors.	<b>K2</b>
<b>CO2</b>	Classify parallel computing paradigms and network topologies.	<b>K2</b>
<b>CO3</b>	Implement shared-memory parallel programming with OpenMP.	<b>K3</b>
<b>CO4</b>	Design and implement parallel algorithms using distributed-memory parallel programming with MPI	<b>K3</b>

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

**CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										3
CO2	3	2										3
CO3	3	3	3	2								3
CO4	3	3	3	2								3

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Introduction to High Performance Computing for Scientists and Engineers	Georg Hager Gerhard Wellein	CRC Press	1/e, 2011
2	High Performance Computing: Modern Systems and Practices	Thomas Sterling, Maciej Brodowicz, Matthew Anderson	Morgan Kaufmann	1/e, 2017

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Parallel and High-Performance Computing	Robert Robey Yuliana Zamora	Manning Publications	1/e, 2021
2	High-Performance Computing	Charles Severance Kevin Dowd	O'Reilly Media	2/e, 1998
3	Computer Architecture And Parallel Processing	Kai Hwang Faye Alaye Briggs	McGraw-Hill	1/e, 1984
4	Computer Architecture: A Quantitative Approach	John L. Hennessy David A. Patterson	Morgan Kaufman	6/e, 2017

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	<a href="https://nptel.ac.in/courses/106108055">https://nptel.ac.in/courses/106108055</a>
2	<a href="https://nptel.ac.in/courses/106108055">https://nptel.ac.in/courses/106108055</a>
3	<a href="https://nptel.ac.in/courses/106108055">https://nptel.ac.in/courses/106108055</a>
4	<a href="https://nptel.ac.in/courses/128106014">https://nptel.ac.in/courses/128106014</a>