Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		L	T	P	L	T	P	Total
CE922	High Performance Computing (HPC)	4	--	--	4	--	--	4
		Examination Scheme						
		ISE		MSE		ESE		
		10		30		100 (60% Weightage)		

Pre-requisite Course Codes		CE44, CE45, CE62
At the end of successful completion of the course, students will be able to		
Course Outcomes	CO1	Understand the different parallel computing approaches and platforms to achieve High Performance Computing.
	CO2	Determine the communication pattern and network technology for High Performance Computing
	CO3	Design High Performance Computing System using MPI and OpenMP.
	CO4	Perform heterogeneous Computing using GPGPU and OpenCL.

Module No.	Unit No.	Topics	Ref.	Hrs.
1	1.1	**Parallel Computing Models –** Computing History, Multiprocessor and Multicomputer, Multi-vector and SIMD Computers, PRAM and VLSI Models, Architectural Developmental Tracks	1	3
	1.2	**Program and Network Properties** – Conditions and Parallelism, Program Partitioning and Scheduling, Program Flow Mechanisms, System Interconnect Architectures	1	3
	1.3	**Principle of Scalable Performance** – Performance Metrics and Measures, Parallel Processing Applications, Speedup Performance Laws, Scalability Analysis and Approaches	1	3
2	2.1	**Communication 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	2	3
	2.2	**High Speed Networks** – Evolution, Design Issues, Fast Ethernet, High Performance Parallel Interface (HiPPI), Asynchronous Transfer Mode (ATM), Scalable Coherent Interface (SCI), ServerNet, Myrinet, Memory Channel, Synfinity	3	5
	2.3	**Lightweight Messaging Systems** - Latency/Bandwidth Evaluation, Traditional Communication Mechanisms, Lightweight Communication Mechanisms, Kernel-Level Lightweight	3	4

		Communications, User-Level Lightweight Communications		
3	**3.1**	**Active Messages (AM) -** AM Programming Model, AM Implementation, Analysis, Programming Models on AM	3	3
	3.2	**Analytical Modeling** - Sources of Overhead in Parallel Programs, Performance Metrics for Parallel Systems, The Effect of Granularity on Performance, Scalability of Parallel Systems, Minimum Execution Time and Minimum Cost-Optimal Execution Time, Asymptotic Analysis of Parallel Programs, Other Scalability Metrics	2	4
	3.3	**Parallel Programming Design** – Preliminaries Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models, The Task/Chanel Model, Foster's Design Methodology.	2,4	5
4	**4.1**	**Message-Passing Interface (MPI)** – Model, Interfaces, Functions, Circuit Satisfiability Problem	4	4
	4.2	**MPI Examples** - Sieve Eratosthenes, Flyod's Algorithm, Performance Analysis, Matrix-Vector Multiplication, Document Classification	4	3
	4.3	**Shared-Memory Programming & OpenMP –** Model, Loops, critical sections, Reductions, Data and Functional parallelism, Conjugate and Jacobi Method.	4	3
5	**5.1**	**Introduction to OpenCL** – Execution Environment, Memory Model, Writing Kernel, OpenCL Device Architectures,	5	3
	5.2	**OpenCL Concurrency –** Concurrency and Execution Model, Synchronization,	5	3
	5.3	**CPU/GPU OpenCL Implementation** – OpenCL on an AMD Phenom II X6 and Radeon HD6970 GPU	5	3
Total				**52**

In-Semester Examination (ISE): The assessment includes the submission of a term paper by each student on the contemporary work related to High Performance Computing.

References:

[1] Kai Hwang, Naresh Jotwani, "*Advanced Computer Architecture: Parallelism, Scalability, Programmability*", Mcgraw-Hill Education, SECOND Edition, 2008.

[2] Ananth Grama, "*Introduction to Parallel Computing*", Addison Wesley, SECOND Edition, 2003.

[3] Rajkumar Buyya, "*High Performance Cluster Computing: Architectures and Systems Volume 1*", Prentice Hall PTR, FIRST Edition, 1993.

[4] Michael J. Quinn, "*Parallel Programming in C with MPI and OpenMP*", McGraw HIll, FIRST Edition, 2003

[5] Benedict Gaster, Lee Howes, David R. Kaeli, Perhaad Mistry, Dana Schaa, "*Heterogeneous Computing with OpenCL*", Morgan Kaufmann, FIRST Edition, 2011