CourseCode	Course Name	Credit
CSDLO6011	High PerformanceComputing	03

Course Objectives: Students will try to:

1. Learn the concepts of high-performance computing.
2. Gain knowledge of platforms for high performance computing.
3. Design and implement algorithms for parallel programming applications.
4. Analyze the performance metrics of High Performance Computing.
5. Understand the parallel programming paradigm, algorithms and applications.
6. Demonstrate the understanding of different High Performance Computing tools.

Course Outcomes: Students will be able to:

1. Understand the fundamentals of parallel Computing.
2. Describe different parallel processing platforms involved in achieving High PerformanceComputing.
3. Demonstrate the principles of Parallel Algorithms and their execution.
4. Evaluate the performance of HPC systems.
5. Apply HPC programming paradigm to parallel applications
6. Discuss different current HPC Platforms.

Prerequisite: Computer Organization, C Programming, Data structures and Algorithm Analysis.

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**
0	Prerequisite	Computer Organization, C Programming, Data structures andAlgorithm Analysis.	**02**
I	Introduction	**Introduction to Parallel Computing:** Motivating Parallelism, Scope of Parallel Computing, Levels of parallelism (instruction,transaction, task, thread, memory, function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-drivenComputation). **Self-learning Topics:** Parallel Architectures: Interconnectionnetwork, Processor Array, Multiprocessor.	**05**

II	Parallel Programming Platforms	**Parallel Programming Platforms:** Implicit Parallelism:Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs inParallel Machines. **Self-learning Topics:** Trends in Microprocessor & Architectures,Limitations of Memory System Performance.	**04**
III	Parallel Algorithm And Concurrency	**Principles of Parallel Algorithm Design:** Preliminaries,Decomposition Techniques, Characteristics of Tasks andInteractions, Mapping Techniques for Load Balancing, Basic Communication operations: Broadcast and ReductionCommunication types. **Self-learning Topics: Parallel Algorithm Models**	**09**
IV	Performance Measures for HPC	**Performance Measures :** Speedup, execution time, efficiency,cost, scalability, Effect of granularity on performance, Scalability of Parallel Systems, Amdahl's Law, Gustavson's Law. **Self-learning Topics:** Performance Bottlenecks.	**05**
V	Programming Paradigms for HPC	**Programming Using the Message-Passing Paradigm :** Principles of Message Passing Programming, The BuildingBlocks: Send and Receive Operations, MPI: the Message Passing Interface, Topology and Embedding. **Parallel Algorithms and Applications :**	**09**
		One-Dimensional Matrix-Vector Multiplication, Graph Algorithms, Sample Sort, Two-Dimensional MatrixVectorMultiplication. **Self-learning Topics:** Introduction to OpenMP.	
VI	General Purpose Graphics Processing Unit(GPGPU) Architecture and Programming	OpenCL Device Architectures, Introduction to OpenCL Programming. **Self-learning Topics:** Introduction to CUDA architecture, andIntroduction to CUDA Programming.	**05**

Text Books:

1. AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar , “Introduction to Parallel Computing”, Pearson Education, Second Edition, 2007.
2. Kai Hwang, Naresh Jotwani, “Advanced Computer Architecture: Parallelism, Scalability, Programmability”, McGraw Hill, Second Edition, 2010.
3. Edward Kandrot and Jason Sanders, “CUDA by Example – An Introduction to General Purpose GPU Programming”, Addison-Wesley Professional ©, 2010.
4. Georg Hager, Gerhard Wellein, “Introduction to High Performance Computing for Scientists and Engineers", Chapman & Hall / CRC Computational Science series, 2011.
5. Benedict Gaster, Lee Howes, David Kaeli, Perhaad Mistry, Dana Schaa , “Heterogeneous Computing with OpenCL” , 2nd Edition, Elsevier, 2012.

Reference Books:

1. Michael J. Quinn, “Parallel Programming in C with MPI and OpenMP”, McGraw-Hill International Editions, Computer Science Series, 2008.
2. Kai Hwang, Zhiwei Xu, “Scalable Parallel Computing: Technology, Architecture, Programming”, McGraw Hill, 1998.
3. Laurence T. Yang, MinyiGuo, “High- Performance Computing: Paradigm and Infrastructure” Wiley, 2006.
4. Fayez Gebali, “Algorithms and Parallel Computing”, John Wiley & Sons, Inc., 2011.

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc21_cs46/preview
2.	https://onlinecourses.nptel.ac.in/noc22_cs21/preview

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.

End Semester Examination: Some guidelines for setting the question papers are as:

- Weightage of each module in end semester examination is expected to be/will be proportional to number of respective lecture hours mentioned in the syllabus.
- **Question paper format**
- Question Paper will comprise of a total of **six questions each carrying 20 marks. Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a)from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered.

- **Suggestion: Laboratory work based on the above syllabus can be incorporated as amini project in CSM601: Mini-Project.**