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**MANIPAL INSTITUTE OF TECHNOLOGY**  
**MANIPAL**  
*(A constituent unit of MAHE, Manipal)*

**I SEMESTER M.TECH. (COMPUTER SCIENCE AND ENGINEERING)**

**END SEMESTER EXAMINATIONS, NOVEMBER - 2024**

**HIGH PERFORMANCE COMPUTING SYSTEMS [CSE 5116]**

**Date: 25/11/2024 [9:30 AM – 12:30 PM]**

Time: 3 Hours

MAX. MARKS: 50

*Instructions: Answer ALL the questions.*

- 1A. Write an OpenMP program that divides the work into sections, where each section performs a different task in parallel. Use sections directive in your program in which one of the sections calculates the product of N natural numbers and another section finds the sum of those natural numbers. At the end, add the results from each section. **4M**
- 1B. With neat diagram demonstrate the importance of the time-shared common bus interconnection network system. List out the advantages and disadvantages of this interconnection network. **4M**
- 1C. Discuss the application of parallel processing in the field of Engineering and Cybersecurity. **2M**
- 2A. Write an MPI program to add elements of an array. Let the two slave processes do the task of adding parts of the array allocated to it. Both slaves send the partial sums done by them back to the root process to compute the final sum. Use only the point-to-point communication APIs (MPI\_Send and MPI\_Recv) in your program. **5M**
- 2B. Define the two phases involved in each iteration of Odd-Even transposition sorting algorithm. **3M**
- 2C. Identify and write the appropriate MPI API with its arguments and suitable example to each of the following:
  - (i) One process (root) sends data to all the other processes in the same communicator
  - (ii) All the processes collect data from all other processes in the same communicator, and perform an operation on the data. **2M**
- 3A. Design a mesh interconnection network of size 3 x 3. Also obtain the Chordal ring network of the same from your design. **5M**
- 3B. A programmer wants to know the time taken for a kernel execution. Help the programmer by writing the all CUDA related APIs with program structure. **5M**
- 4A. Availability of a parallel computer system is Shuffle-exchange SIMD. There are N elements in an array to be partitioned among p number of processors in Shuffle-exchange where  $p = N$ . Construct a parallel algorithm to perform summation by the respective processors after partitioning the numbers and also obtain the final sum. What is the time complexity of your algorithm? **4M**
- 4B. A work-group is defined to have 128 work-items. If the total number of work-items per array is 4096, recognize how many workgroups get created. Use any generalized diagram, to narrate how work-items are related to ND-range and grouped in workgroups. **4M**

- 4C.** Sketch the diagram for mapping the memory model defined by OpenCL to the architecture of GPU. **2M**
- 5A.** Prepare a list by organizing all the steps involved in OpenCL program implementation with the supporting APIs. Name the relevant API(s) appearing in every step. **4M**
- 5B.** Develop an efficient OpenCL kernel that multiplies every element in a matrix of size  $N \times N$  by a scalar quantity to get the resultant matrix. **3M**
- 5C.** Design  $8 \times 8$  baseline multistage network. Explain your design methodology. **3M**