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MANIPAL INSTITUTE OF TECHNOLOGY

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I SEMESTER M.TECH (CSE) MIDTERM EXAMINATIONS SEPT 2025

MIDTERM EXAMINATION

HIGH PERFORMANCE COMPUTING SYSTEMS [CSS 5103]

Date: 17-09-2025

Time: 2:15 PM – 3:45 PM

Max. Marks: 30

Instructions to Candidates:

- ❖ Answer ALL the questions

Q1. What are the Directives in OpenMP? Interpret and explain the role of *parallel* and *sections* directives in OpenMP. 3M

Q2. Explain how the *FOR* loop being inside the *#pragma* is handled by the threads?
An attempt to multiply (element-wise multiplication) two 1D array with N elements (here $N = 10$) is done. A *FOR* loop is required to be used in your code for multiplication under *#pragma* as *for* ($i = 0; i < 10; i++$). But your program uses only two threads. Develop an OpenMP program and give your analysis to the possible output of your program. 4M

Q3. Write and explain a MPI routine with its arguments that combines data from all processes in the communicator using a specified operation to store the result in the root and this result is distributed to all other processes belonging to the same communicator. 2M

Q4. Construct an MPI program to read a number N through a root process. See that this number is communicated to rest of all the processes created. Further each process (including root process) calculates the sum up to N and then all processes send it to root to calculate the final sum to display by the root process. You need to use user friendly statements wherever essential. Use the collective communication APIs in your program. 4M

Q5. Develop an MPI program to send distinct data from each process to every other process. Assume that we have number of processes ($p=4$ processes). See that initially each process holds the data as

Process 0 holds: [00, 01, 02, 03, 04, 05, 06, 07]
Process 1 holds: [10, 11, 12, 13, 14, 15, 16, 17]
Process 2 holds: [20, 21, 22, 23, 24, 25, 26, 27]
Process 3 holds: [30, 31, 32, 33, 34, 35, 36, 37]

After your program is run, each process has received the data as

Process 0 receives: [00, 01, 10, 11, 20, 21, 30, 31]
Process 1 receives: [02, 03, 12, 13, 22, 23, 32, 33]
Process 2 receives: [04, 05, 14, 15, 24, 25, 34, 35]
Process 3 receives: [06, 07, 16, 17, 26, 27, 36, 37]

Use an appropriate collective communication routine for this purpose.

5M

Q6. Sketch a CUDA device memory model diagram that uses 3 blocks with each block using one thread in it. Discuss the memory hierarchy that appears in CUDA device. **3M**

Q7. Construct an efficient CUDA kernel to meet the following:

It is required to generate the sum of the cubes of the principal diagonal elements of a given matrix A of size $N \times N$. In your kernel use only the threadIdx.x to find the thread ID.

For Eg, if the given matrix A is of size 3×3 :

	1	2	3
Matrix A =	4	5	6
	7	8	9

sum of the cubes of the principle diagonal elements = 855 (i.e. $1^3 + 5^3 + 9^3 = 855$) **4M**

Q8. Develop an efficient CUDA program to generate an output matrix of size $N \times N$ from given input matrix of size $N \times N$.

For eg:

	1	2	3
Output matrix =	4	5	6
	7	8	9

from the following input matrix

	A	B	C
Input matrix =	D	E	F
	G	H	I

5M