[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 5055 **L**

Unique Paper Code : 2344000033

Name of the Paper : Introduction to Parallel Programming

Name of the Course : **Computer Science General Elective**

Semester : VIII

Duration : 3 Hours Maximum Marks : 90

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. **SECTION A** is compulsory.
3. Attempt any **4** questions from **SECTION B.**
4. Parts of a question must be answered together.

Section A

Q1. Fill in the blanks: **(6)**

(a)
i. The _____ MPI function is used to determine the number of processes.
ii. A _____ network is one in which there is only one path between any pair of nodes
iii. The _____ MPI function is used to label of the calling process.
iv. Every process that belongs to a communicator is uniquely identified by its _____.
v. _____ MPI function does not suffer from the circular deadlock problems of MPI_Send and MPI_Recv.
vi. In a _____ network, each node has a direct communication link to every other node in the network.

(b) Write a program to compute the product of two dense matrices of size n×n. Transform this code to schedule each of these threads concurrently on multiple processors. **(4)**

P.T.O.

(c) What is critical section? In a producer-consumer problem a producer thread generates a task and inserts it into a task-queue. The consumer thread extracts task from the queue and executes them one at a time. Since there is concurrent access to the task-queue, these accesses must be serialized using critical blocks. Write the program to implement producer-consumer problem using OpenMP. (4)

(d) What is parallel programming? List any two applications of parallel programming. (4)

(e) Give the output of the following program: (4)

i)
```
int sum = 0;
#pragma omp parallel for reduction (+: sum)
for (int i = 1; i <= 5; i++)
   sum += i;
printf("%d", sum)
```

ii)
```
int x = 0;
#pragma omp parallel private(x)
{
 x = omp_get_thread_num();
 printf("%d", x)
}
```

(f) Write the code fragment for the following: (4)
i) firstprivate
ii) lastprivate

(g) Given two vectors A = [2, 4, 6, 8] and B = [1, 3, 5, 7], perform the parallel computation of dot product using two processors. (4)

Section B

Q2 (a) What is parallel random access machine (PRAM)? Explain four subclasses of PRAM. (8)

(b) List any two characteristics of threaded programming models. Write the code fragment for the following directives: (7)
i) for
ii) parallel
iii) section

Q3 (a) Explain any four characteristics of each of the following: **(8)**
i) Shared-Address-Space Platforms
ii) Message-Passing Platforms

(b) What is the function of nested parallel directive used in OpenMP? The following is the code for multiplying two matrices A and B to yield matrix C. **(7)**

```
for(i = 0; i < dim; i++) {
    for(j = 0; j < dim; j++) {
        c[i][j] = 0;
        for(k = 0; k < dim; k++) {
            c[i][j] += a[i][k] * b[k][j];
        }
    }

}
```

Modify the above program using nesting parallel directive.

Q4 (a) Write a shared memory program to process marks of five students. The program should take the roll number and marks of student in four subjects as input and find the grade of each student. (Grade A: Marks≥80; Grade B: 80>Marks≥60; Grade C: Marks<60) **(8)**

(b) What MPI functions are used to write a complete message-passing program that can sort a list of numbers using the odd-even sorting algorithm? Also, sort the array [3, 2, 3, 8, 5, 6, 4, 1] on six processors using odd-even sorting. **(7)**

Q5 (a) What are non-blocking communication operations? Write the code fragment for non-blocking send and receive operations supported by MPI. Write a program to demonstrate how by using non-blocking communication operations, deadlock associated with their blocking counterparts can be removed. **(8)**

(b) What is a race condition? Write a parallel program to find sum and product of **N** numbers using two different critical sections. **(7)**

Q6 (a) Explain the following network topologies: **(8)**
a) Bus-based Networks
b) Crossbar Networks

(b) What is a superscalar execution? Give an example of a two-way superscalar execution of instructions demonstrating three different code fragments for adding a list of four numbers, and its execution schedule for any one code fragment. (7)

Q7(a) Explain any two MPI calls for the following: (8)
a) point-to-point communications
b) collective communications

(b) Given matrix `M=[1 2 3; 4 5 6; 7 8 9]` and Vector `V=[1, 1, 1]` (7)
compute the matrix-vector multiplication in parallel using three processors, where each processor computes one row.

(500)