

**ITCS 4145/5145 Parallel Programming**  
**Final exam**  
**Monday Dec 10th 2007, 5:00 pm - 7:45 pm**

Name: .....

Part I is closed book. Do not refer to any materials for this part. Part II is open book. You may refer to any materials for this part (but not others in the class). Return Part I to get Part II.

Total /60  
Part I /40  
Part II /20

**Part I**

Do not refer to any materials for this part

Qu. 1 Answer each of the following briefly:

(a) Why is modeling the motion of astronomical bodies (in a simplistic fashion) an  $O(N^2)$  problem where there are  $N$  bodies? Suggest one way the program could be mapped onto a parallel computer to use multiple processes. 2

(b) Using the derivation of Amdahl's law as a basis, derive a formula for Speed-up factor given that there are  $p$  processors,  $f$  is the fraction of the computation that must be done *in parallel*, and the parallelizable part of the program can be divided into  $s$  parallel parts, where  $s < p$ . 4

- (c) What does the abbreviation MPI stand for and what is it? 2
- (d) In MPI, if one wishes to have each process do something different, how is that coded? 2
- (e) Suggest one reason why a MPI computation would execute slower on a system with two processors than on a system with one processor. 2
- (f) Identify one MPI routine that does not use a communicator as an argument. 2
- (g) Suppose there is an array  $A[n]$  and one wishes to send  $A[0]$  and  $A[1]$  to process 1,  $A[2]$  and  $A[3]$  to process 2,  $A[4]$  and  $A[5]$  to process 3,  $A[6]$  and  $A[7]$  to process 4,... etc. How can one most efficiently do this in MPI? 2

(h) In the command:

```
mpirun -np 10 ./prog1
```

what does `./` specify?

2

(i) Describe one way the time of execution of an MPI program can be obtained.

2

(j) Suppose one wishes to compute  $1 - \pi/4$  using a Monte Carlo method. Suggest one way this could be done without computing  $\pi/4$  first.

2

(k) How many pipeline stages are needed to determine whether 13 is prime using a pipeline approach? Explain how you got your answer.

2

- (l) What does the MPI routine `MPI_sendrecv()` do? 2
- (k) What is the prefix sum calculation? 2
- (l) What is meant by a thread-safe routine? 2
- (m) What is a monitor routine? 2
- (n) Why would one sometimes compute the same calculation in more than one process rather than compute it once and send its value to the other processes. Under what circumstances would computing the same calculation in more than one process lead to incorrect results? 2

(o) Is following a Bitonic sequence:

4 6 9 7 4 2 3

Explain your answer.

2

(p) Explain how to achieve a computational time complexity of  $O(\log n)$  for matrix multiplication using  $n^3$  processors.

2

(q) Why is the Gauss-Seidel relaxation method of solving Laplace's equation (heat distribution problem) by iteration not suitable for parallelization?

2

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Qu. 2 Write a complete MPI program to perform matrix-vector multiplication using the systolic array approach for a 4 x 4 matrix and a 4 x 1 vector using 4 processes.

12

*Provide clear explanation of how the program works, and comments in your code to help the grader! If I do not understand the code, I will assume it is incorrect.*

6

