

Spring 2026  
Exam II (scaled to 30 points)  
Thursday, April 9

**DO NOT OPEN THIS EXAM UNTIL YOU ARE  
INSTRUCTED TO DO SO**

Name: \_\_\_\_\_ . Student ID No. \_\_\_\_\_

1. **NO TALKING FROM WHEN YOU ENTER THE EXAM ROOM UNTIL YOU HAVE EXITED THE EXAM ROOM!** Any violation will earn you an F on the exam, at a minimum.
  2. If you have a question, come to the front of the room and whisper very quietly to Nitin.
  3. Please note any concerns of interpretation of a question on your exam.
  4. **Write the exam with a dark colored pen or pencil.** Light colored pens or pencils do not scan well.
- **Plagiarism** will earn you an F in the course and a recommendation of expulsion from the university.
    - a. You may not refer to any material outside of this exam.
    - b. That is, you may **not** refer to notes, books, papers, calculators, phones, watches, other electronic devices, classmates, classmates' exams, and so forth.
    - c. **Do not talk to fellow students at any time while in the exam room.**
  - Answer all questions on these pages. No code or pseudo-code is necessary – just a precise and concise explanation and justification.
  - *Unsupported work will receive no credit.*



Q1 (6 pts) **Hypercube.** Given a hypercube of size  $n$  with one piece of data stored per processor, give an asymptotically cost-optimal algorithm of minimal asymptotic running time to compute the summation of the  $n$  values. At the end of the algorithm, all processors should know the final result. Justify your answer.



Q2 (6 pts) **Mesh-of-Trees.** Given a mesh-of-trees of base size  $n$ , with one value stored per mesh processor, where only one of the mesh processors has the value 1, give an algorithm to determine the location of the mesh processor with the value 1. At the end of the algorithm, all mesh processors should know the location of the processor containing the 1. Efficiency counts! Justify your answer.



### Q3 (7 pts) **Combinational Circuit.**

- (i) (3 pts) Draw a diagram that demonstrates the principles of a Bitonic merge unit for  $n$  input items. You may, but do not need to, provide an explanation to accompany your diagram.
- (ii) (2 pts) Given  $n$  inputs, what is the running time of Bitonic Merge as implemented on a combinational circuit? Justify your answer.
- (iii) (2 pts) Given  $n$  inputs, what is the running time of Bitonic Sort as implemented on a sequential computer? Justify your answer.



**Q4 (5 pts) Lower Bounds on Sorting.** Give a lower bound on the time to sort  $n$  pieces of data based on the following configurations. Quality counts! Justify your answers.

- a. Input and output of data is one per processor on a mesh of size  $n$ .
- b. Input and output of data is one per processor on the mesh of a mesh-of-trees of base size  $n$ .
- c. Input and output of data is one per leaf processor on a tree with  $n$  leaves.
- d. Input and output of data is one per base processor on a pyramid of base size  $n$ .
- e. Input and output of data is one per processor on a hypercube of size  $n$ .



Q5 (6 pts) **Mesh.** Given a mesh of size  $n$  with one piece of data per processor, give an asymptotically time-optimal algorithm to determine the parallel prefix sum of the data. You should use row-major ordering of the processors for indexing. Justify your answer.



## Extra Credit

1. (1 pt) What does Dr. Miller consider the best time of the year in sports? Circle one.
  - a. The Masters
  - b. NCAA March Madness
  - c. The World Series
  - d. The World Cup
  
2. (1 pt) What instrument did Dr. Miller play professionally.
  - a. Guitar
  - b. Keyboards
  - c. Drums
  - d. Bass

