Important: This is an open book test. You can use any books, notes, or paper, but not exchange anything with other students. You are not allowed to use any electronic/communication devices, including a calculator. *Do not log into the computer during the test. Switch off your cell phones.* Any calculations and rough work can be done on the back side of the test pages. You will lose five points for not writing your name.

1. [10 pt] You are given an array of n records, each containing the x and y coordinates of a house. You are also given the x and y coordinates of a railroad station. Design a parallel algorithm to find the house closest to the railroad station (as the crow flies). Draw a task/channel diagram to show primitive tasks.

2. [10 pt] Suppose we have chosen a block agglomeration of n elements (labeled $0, 1, \ldots, n-1$) to p processes (labeled $0, 1, \ldots, p-1$) in which process i is responsible for elements $\lfloor in/p \rfloor$ through $\lfloor (i+1)n/p \rfloor - 1$. How many elements will be handled by the last process?

3. [10 pt] For a problem size of interest, 6% of the operations of a parallel program are inside I/O functions that are executed on a single processor. What is the minimum number of processors needed in order for the parallel program to exhibit a speedup of 10?

4. [10 pt] Assume `grid_comm` is a communicator with a Cartesian topology that organizes processes into a 2D grid. Write a code segment that partitions the process grid into columns. At the end of the code segment, each process's value of `col_comm` should be a communicator containing the calling process and all other processes in the same column of the process grid, but no others.

5. [10 pt] Assigning one process at a time to each worker allowed us to balance workload in the manager/worker paradigm. Give an example where this scheme may run into problems.