CMT106 Worksheet

1. Suppose we have a block-cyclic data distribution with block size 3×4 that is used to distribute an array, A, over a 2×6 processor mesh.
   a. What is the position in the processor mesh of the processor holding array element (17, 72)?
   b. On a distributed memory computer each processor holds its part of the array A in a local array, L. What element of the array A is stored at location (2,4) of L in the processor at location (1,3) of the processor mesh?
2. Suppose we have a block-cyclic data distribution with block size 5×6 that is used to distribute an array, A, over a 3×4 processor mesh.
   a. What is the position in the processor mesh of the processor holding array element (101, 97)?
   b. On a distributed memory computer each processor holds its part of the array A in a local array, L. What element of the array A is stored at location (7,5) of L in the processor at location (2,3) of the processor mesh?
3. The nodes of a d-dimensional hypercube are mapped onto a $2^{d1}\times 2^{d0}$ mesh using a Gray code mapping, where d = d0 + d1. Thus, node n is mapped to location (i,j), where $0\leq n<d$, $0\leq i<d1$, and $0\leq j<d0$.
   a. If $d_0 = 2$ and $d_1 = 3$, to which location in the mesh is node 23 mapped?
   b. If $d_0 = 2$ and $d_1 = 2$, which node is mapped to location (3,2) in the mesh?
   c. If $d_0 = 5$ and $d_1 = 4$, which node is mapped to location (10,22) in the mesh?
   d. If $d_0 = 5$ and $d_1 = 4$, to which location in the mesh is node 410 mapped?
4. A parallel computer has 4096 processors, each with a peak execution rate of 5 Gflops.
   a. Derive a formula for the maximum possible execution speed of the parallel computer, measured in Gflops, as a function of the serial fraction, α.
   b. What is the largest possible value of α for which the maximum execution speed of the parallel computer is 1000 Gflops?
5. An image analysis algorithm acts on $M = 2^m$ data items. The sequential version of this algorithm consists of m iterations, each of which involves 5M floating-point computations. The time for a floating-point computation is denoted by t_{calc}. The parallel version of the algorithm performs the same computations as the sequential algorithm, and evenly distributes the M data items over N processes, where $N = 2^n$ and $n < m$. In the parallel algorithm no communication between processes is needed in the first m-n iterations. However, in the remaining iterations each process exchanges all of its data items with the corresponding data items of one other process. The time to exchange one floating-point number on one process with a float-point

number on another process is denoted by t_{comm}. (Note that: $m = \log_2 M$, and $n = \log_2 N$.)

a. Give the formula for the time to execute the sequential algorithm, $T_{seq}(M)$.
b. Give the formula for the time a process spends communicating in the parallel version of the algorithm.
c. Give the formula for the execution time of the parallel version of the algorithm, $T_{par}(M,N)$.
d. Express the speed-up of the algorithm in terms of M, N, and the ratio $\tau = t_{comm}/t_{calc}$.