1. List the members of your group below:

2. Let $\oplus$ denote a associative binary operator and let $z$ denote its identity element (so that $z \oplus x = x$ for all $x$). Let $A = a_1, \ldots, a_n$ be an array of elements from the domain of $\oplus$. We define the reduce operation as $R(\oplus, I, A) = a_1 \oplus a_2 \oplus \cdots \oplus a_n$ for $n \geq 0$ (so that $R(\oplus, I, A) = 0$ if $n = 0$).

Compute $R(\oplus, I, A_1)$ where $A_1 = (3, 1, 4, 1, 5, 9, 2, 6, 5, 3, 5)$ and $\oplus$ is (1) the usual integer addition and (2) string concatenation. What is $z$ for these two cases?

3. The result of the *all prefix sums*, or *scan*, operator applied to a sequence of numbers $a_1, \ldots, a_n$ is the sequence $b_1, \ldots, b_n$, where $b_i = \sum_{j=1}^{i} a_i$ for $1 \leq i \leq n$. (The operator may be generalized beyond addition to any associative operator $\oplus$, as in Question 2.) The *prescan* operator is similar, but returns the sequence $0, b_1, b_2, b_{n-1}$ instead.

Compute the scan and prescan of the array $A_1$ of Question 2.
4. Provide a naive \(O(n)\) sequential algorithm for \textit{reduce}.

5. Provide a parallel algorithm for \textit{reduce} that runs in \(O(\log n)\) time. How many processors does your algorithm require, as a function of \(n\)? Justify the correctness and running time of your algorithm briefly.
6. Modify your algorithm of Question 5 to use a parameterized number of processors, \( p \), yielding a running time of \( O(n/p + \log p) \). Justify the correctness and running times of your algorithm.
7. Repeat Questions 4–6 for the scan operation.