**Blue Waters Petascale Semester Curriculum v1.0**

**Unit 4: OpenMP**

**Lesson 9: Sieve of Eratosthenes**

**Exercise Instructions for Students**

*Developed by David A. Joiner for the Shodor Education Foundation, Inc.*



*Except where otherwise noted, this work by The Shodor Education Foundation, Inc. is licensed under CC BY-NC 4.0. To view a copy of this license, visit*[*https://creativecommons.org/licenses/by-nc/4.0*](https://creativecommons.org/licenses/by-nc/4.0)

*Browse and search the full curriculum at*[*http://shodor.org/petascale/materials/semester-curriculum*](http://shodor.org/petascale/materials/semester-curriculum)

*We welcome your improvements! You can submit your proposed changes to this material and the rest of the curriculum in our GitHub repository at*[*https://github.com/shodor-education/petascale-semester-curriculum*](https://github.com/shodor-education/petascale-semester-curriculum)

*We want to hear from you! Please let us know your experiences using this material by sending email to* [*petascale@shodor.org*](mailto:petascale@shodor.org)

The Sieve of Eratosthenes is a classic algorithm for determining a large list of prime numbers, and if your goal is to calculate a complete and comprehensive list of primes up to some value, is likely the fastest algorithm that you can use.

It works as follows. You start with a list of all numbers up to. (For our computer algorithm we will in practice count to N-1 to make our array syntax easier). For each of these numbers, construct a list of whether the number is or is not prime. In the beginning, assume all numbers are prime until proven otherwise. This might be most easily done with an array of ints or booleans, so that list[5]==0 would imply that 5 is prime, whereas list[4]==1 would imply that 4 is not.

You have been provided a starter code that implements the Sieve of Eratosthenes algorithm in C, with additional includes and profiling instructions for OpenMP. Your goal is to discuss, plan, and implement a parallelization of the problem in OpenMP, and test the performance of your implementation.

1. Consider the starter code. Compile and run it as you would for any OpenMP program. gcc -o sieve.starter sieve.starter.c -lm -fopenmp For increasing list lengths, note the running time. Does the algorithm scale as expected?

2. For the starter code, note the amount of time required to build a list. Before attempting parallelization, make a hypothesis as to how long the list might need to be before you begin to see the benefit of parallelism.

3. Looking at the nested loop, determine whether there are any loop carried dependencies in either the inner or outer loop. What is the implication of a loop carried dependency in parallelization?

4. Implement a plan to parallelize using OpenMP. Focus on the outermost loop without a loop carried dependency. Parallelize your code.

5. Using your parallel code, compare parallel efficiency as you increase the problem size and number of threads. Display your results in a table, and discuss the effectiveness of parallelization for this problem at different problem sizes.