Learning objective: parallelize the reduce phase. The parallelization of the reduce phase is illustrated with an algorithm to estimate the value of \(\pi\).

Exercise 1: pi computation algorithm
What is the area of a circle with radius 1?
Let us draw a random point uniformly in the square defined by the coordinates \((0,0)\) and \((1,1)\). What is the probability that this point is in the circle of radius 1 and which center is \((0,0)\)?
By relying on the law of large numbers, specify an algorithm to estimate the value of \(\pi\) by drawing successively \(n\) random points.

Exercise 2: stream formulation with generate
Propose a stream algorithm with the method \texttt{generate} to estimate the value of \(\pi\).

Exercise 3: stream formulation with range
The method \texttt{generate} leads to a stream that is unfortunately difficult to parallelize because it does not convey the size and the splitting step is thus inefficient.
Propose an alternative using the method \texttt{range}.

Exercise 4: tryAdvance
In the following two exercises, we consider the implementation of a custom spliterator to split and iterate over a stream while retaining the size information, which is not the case by default with \texttt{generate} and \texttt{limit}.
We assume the spliterator is initialized with the appropriate supplier and size (\texttt{supplier} and \texttt{size}).

```java
class MySpliterator<T> implements Spliterator<T> {
    long size;
    Supplier<T> supplier;
    MySpliterator(Supplier<T> supplier, long size) {
        this.size = size;
        this.supplier = supplier;
    }
}
```

Let us consider the following simplified prototype: \texttt{boolean tryAdvance(Consumer<T> consumer)}. This function returns \texttt{true} if there are still elements in the stream, \texttt{false} otherwise. Its main purpose is to apply the consumer (with method \texttt{Consumer.accept(T)}) on a newly generated element (with method \texttt{Supplier.get()} of the stream.
Propose an implementation of this method.

Exercise 5: trySplit
The method \texttt{trySplit} returns a new spliterator with half the elements or null if the stream cannot be split. Its prototype is \texttt{Spliterator<T> trySplit()}. Propose an implementation of this method.
Exercise 6: factorial
Write a stream that computes the factorial of $n$ in parallel.
Discuss its parallelization compared to the parallelization of computing the sum of the first $n$ numbers of the Fibonacci sequence.

Exercise 7: matrix multiplication
We assume that two matrices are given as in the following example:

```java
double[][] m1 = { { 4, 8 }, { 0, 2 }, { 1, 6 } };
double[][] m2 = { { 5, 2 }, { 9, 4 } };
```

In this case, the result of their product must be:

```java
double[][] res = { { 92, 40 }, { 18, 8 }, { 59, 26 } }
```

Propose an implementation with external iterations (with `for` loops).
Replace the most inner loop with a stream.
Propose a complete stream implementation of the matrix multiplication that relies on the method `toArray`, which is a terminal operation that transforms the stream into an array.
Propose and discuss multiple options to parallelize this stream.