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 `generate` to estimate the value of $\pi$.

**Exercise 3: stream formulation with range**

The method `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 `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 `generate` and `limit`.

We assume the spliterator is initialized with the appropriate supplier and size (`supplier` and `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: boolean `tryAdvance(Consumer<T> consumer)`. This function returns `true` if there are still elements in the stream, `false` otherwise. Its main purpose is to apply the consumer (with method `Consumer.accept(T)`) on a newly generated element (with method `Supplier.get()`) of the stream.

Propose an implementation of this method.

**Exercise 5: trySplit**

The method `trySplit` returns a new spliterator with half the elements or null if the stream cannot be split. Its prototype is `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:

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

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

```
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.