Functions
Lecture Question

Restriction: No state is allowed in this question. Specifically, the keyword "var" is banned. (ie. You are expected to use collection methods)

Question: In a package named "functions" add to the object named Numbers (The object with your fib method) a method named averageInRange that:

• Takes a List of Doubles as a parameter
• Returns a functions that takes 2 Doubles and returns a Double
  • This function will return the average of all the numbers in the List that are between the two input Double
  • Exclude the endpoints
  • The first parameter of the function is the min value and the second is the max value of the range

Testing: In a package named "tests" create a class named "TestAverageInRange" as a test suite that tests all the functionality listed above
One Last Sorting Example
Custom Sorting

• We can sort any type with any comparator

• But what if we want to sort points by their distance from a reference point
  • In general: what if the comparator needs more parameters than just the two elements?

• We can dynamically create a new function with the additional parameters "built-in"
Returning Functions

• We can write a function/method that takes all the needed parameters and returns a function that fits the signature of a comparator

• The distanceComparator method returns a comparator that compares the distance to a reference point

```scala
def distance(v1: PhysicsVector, v2: PhysicsVector): Double = {
  Math.sqrt(Math.pow(v1.x - v2.x, 2.0) + Math.pow(v1.y - v2.y, 2.0) + Math.pow(v1.z - v2.z, 2.0))
}

def distanceComparator(referencePoint: PhysicsVector): (PhysicsVector, PhysicsVector) => Boolean = {
  (v1: PhysicsVector, v2: PhysicsVector) => {
    distance(v1, referencePoint) < distance(v2, referencePoint)
  }
}
```
Returning Functions

- Use `distanceComparator` to create a comparator function when needed
- Can create different comparators with different reference points
- Global state would only allow one comparator at a time

```scala
val referencePoint = new PhysicsVector(0.5, 0.5, 0.0)
val sortedPoints = MergeSort.mergeSort(points, distanceComparator(referencePoint))
```

```scala
def distance(v1: PhysicsVector, v2: PhysicsVector): Double = {
    Math.sqrt(Math.pow(v1.x - v2.x, 2.0) + Math.pow(v1.y - v2.y, 2.0) + Math.pow(v1.z - v2.z, 2.0))
}

def distanceComparator(referencePoint: PhysicsVector): (PhysicsVector, PhysicsVector) => Boolean = {
    (v1: PhysicsVector, v2: PhysicsVector) => {
        distance(v1, referencePoint) < distance(v2, referencePoint)
    }
}
```
Collection Methods

- We can apply first-order functions to compress our code when working with data structures

- We'll see a variety of methods that take functions as parameters to help us work with data
For Each

- Call a function on each elements of a List
- Only use for the side-effects
  - i.e. Not too useful when embracing immutability

```scala
val words: List[String] = List("zero", "one", "two", "three")
words.foreach(println)
```

zero
one
two
three
Filter

- Takes a function of the data type to Boolean
- Returns a new List containing only the elements for which the function returns true

```scala
val words: List[String] = List("zero", "one", "two", "three")
val filteredWords: List[String] = words.filter(_.length > 3)
filteredWords.foreach(println)

s: String => s.length > 3
```
Map

- Takes a function of the data type to another data type
- Returns a new List containing the return values of the function with each element as an input

```scala
val numbers: List[Double] = List(1.0, 2.0, 3.0, 4.0, 5.0)
val numbersSquared: List[Double] = numbers.map(Math.pow(_, 2.0))
numbersSquared.foreach(println)
```

1.0
4.0
9.0
16.0
25.0
Map

- The map method takes 2 type parameters
- We can provide a function that "maps" the elements to a different type
  - The types can be inferred by the types of the provided function

```scala
val words: List[String] = List("zero", "one", "two", "three")
val wordLengths: List[Int] = words.map(_.length)
wordLengths.foreach(println)
```

4 3 3 5
Yield

• As alternate syntax to map, we can use the yield keyword
• Add the keyword yield before the body of a loop
• The last expression of the loop body will be collected at each iteration

```scala
val numbers: List[Double] = List(1.0, 2.0, 3.0, 4.0, 5.0)
val numbersSquared: List[Double] = for(number <- numbers) yield {
  Math.pow(number, 2.0)
}
numbersSquared.foreach(println)
```

1.0
4.0
9.0
16.0
25.0
Yield

• Using yield will create a data structure of the same type as the one being iterated over

• It's not always possible to match the type exactly

• Scala will default to a certain data structure

  • Use toList to convert the default type to a List

```scala
val numbersSquared: List[Double] = (for(number <- 1 to 5) yield {
  Math.pow(number, 2.0)
}).toList
numbersSquared.foreach(println)
```

1.0
4.0
9.0
16.0
25.0
Reduce

- Takes a function that combines two values of the data type into a single value of that type
- Calls this function on all elements
  - Combines the data into a single value
- The first parameter of the function is the accumulator
  - Stores the total value accumulated so far

```scala
val numbers: List[Double] = List(1.0, 2.0, 3.0, 4.0, 5.0)
val sumSquares: (Double, Double) => Double = (a: Double, b: Double) => a + Math.pow(b, 2.0)
val sumOfSquares: Double = numbers.reduce(sumSquares)
println(sumOfSquares)
```

55.0
Reduce

- We can use the _ shorthand with two parameters
- The order of appearance of the _'s is the parameter order
- Cannot use _ shorthand if you need to use an input twice

```scala
val numbers: List[Double] = List(1.0, 2.0, 3.0, 4.0, 5.0)
val sumOfSquares: Double = numbers.reduce(_ + Math.pow(_, 2.0))
println(sumOfSquares)
```

55.0
Fold

- Similar to reduce
- Use fold if you need to initialize your accumulator
- Use fold if you are reducing a different type than the data type

```
val numbers: List[Double] = List(1.0, 2.0, 3.0, 4.0, 5.0)
val mult: Double = numbers.fold(1.0)(_ * _)
println(mult)
```

120.0
Fold

• To accumulate to a type different than the data type
  • Use the left/right version of fold
• Initial value determines the accumulator type
  • This value is returned if the input is the empty list

```scala
val words: List[String] = List("zero", "one", "two", "three")
val totalLength: Int = words.foldLeft(0)(_ + _.length)
val totalLength2: Int = words.foldRight(0)(_.length + _)
println(totalLength)
println(totalLength2)
```

15
15
Fold

- Using fold defaults to foldLeft
  - Start with the first (left-most) element
- To accumulate from the end of the List use foldRight
  - Must reverse the parameter order when using foldRight/reduceRight
    - Accumulator is second parameter, data is first element

```scala
val words: List[String] = List("zero", "one", "two", "three")
val totalLength: Int = words.foldLeft(0)(_ + _.length)
val totalLength2: Int = words.foldRight(0)(_ .length + _)
println(totalLength)
println(totalLength2)
```

15
15
Example - Polynomials
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