COMPSCI 1JC3 C01

Introduction to Computational Thinking

Fall 2018

Assignment 5

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The purpose of Assignment 5 is implement a practical higher-order function. The requirements for Assignment 5 are given below. Please submit Assignment 5 as two files, `Assign_5.hs` and `Assign_5_Test.hs`, to the Assignment 5 folder on Avenue under Assessments/Assignments. Unlike the previous assignments, there is not an extra credit option for Assignment 5. Assignment 5 is due **December 2, 2018 before midnight.** Assignment 5 is worth 4% of your final grade.

Late submissions will not be accepted! So it is suggested that you submit preliminary `Assign_5.hs` and `Assign_5_Test.hs` files well before the deadline so that your mark is not zero if, e.g., your computer fails at 11:50 PM on December 2.

Although you are allowed to receive help from the instructional staff and other students, your submitted program must be your own work. Copying will be treated as academic dishonesty!

1 Background

Using the *trapezoidal rule*, the value of a definite integral

$$\int_a^b f(x)\,dx$$

can be approximated by the summation

$$\sum_{i=1}^{n} \frac{f(x_{i-1}) + f(x_i)}{2} * \frac{b-a}{n}$$

where

$$a = x_0 < x_1 < \cdots < x_n = b$$

and $x_i - x_{i-1} = (b-a)/n$ for all i with $1 \leq i \leq n$. Notice that

$$\frac{f(x_{i-1}) + f(x_i)}{2} * \frac{b-a}{n}$$

is the area of a trapezoid that approximates the area under the graph of f from x_{i-1} to x_i. The approximation becomes more accurate as the parameter n increases in value.

2 Assignment 5

The purpose of this assignment is to create a Haskell module for approximating the definite integral of a function $f : \mathbb{R} \to \mathbb{R}$.

2.1 Requirements

1. Download from Avenue `Assign5_Project_Template.zip` which contains the Stack project files for this assignment. Modify the `Assign_5.hs` file in the `src` folder so that the following requirements are satisfied. Also put your testing code for this assignment in the `Assign_5_Test.hs` file in the `test` folder.

2. Your name, the date, and "Assignment 5" are in comments at the top of your file. `macid` is defined to be your MacID.

3. The file includes a function `definiteIntegral` of type

   ```
   Double -> Double -> (Double -> Double) -> Integer -> Double
   ```

   such that

   ```
   definiteIntegral a b g n
   ```

   computes an approximation to the definite integral

   $$\int_{\mathtt{a}}^{\mathtt{b}} f(x)\,dx$$

   using the trapezoidal rule with `n` partitions and using `g` to represent the function $f : \mathbb{R} \to \mathbb{R}$.

4. Let $h : \mathbb{N}^+ \to \mathbb{R}$ map each positive natural number n to the area between the curves $y = \sqrt[n]{x}$ and $y = x^n$ from 0 to 1. Notice that

   $$\lim_{n\to\infty} h(n) = 1.$$

   The file includes a function `funH` of type

   ```
   Integer -> Double
   ```

   that implements the function h using `definiteIntegral`. You should assume that `funH n` is undefined when $\mathtt{n} \leq 0$.

5. Let $k : \mathbb{R}^+ \to \mathbb{R}$ map each positive real number a to the area between the curve $y = a^x$ and the x-axis from -1 to 1. Notice that

$$\lim_{a \to \infty} k(a) = \infty.$$

   The file includes a function `funK` of type

```
Double -> Double
```

   that implements the function k using `definiteIntegral`. You should assume that `funK a` is undefined when `a` ≤ 0.

6. Your file can be imported into GHCi and all of your functions perform correctly.

2.2 Testing

Include in your file a test plan for all three functions mentioned above. The test plan must include at least three test cases for each function. Each test case should have following form:

`Function:` Name of the function being tested.
`Test Case Number:` The number of the test case.
`Input:` Inputs for function.
`Expected Output:` Expected output for the function.
`Actual Output:` Actual output for the function.

In addition, your test plan must include at least one QuickCheck case for each of the three functions. Each QuickCheck case should have following form:

`Function:` Name of the function being tested.
`Property:` Code defining the property to be tested by QuickCheck.
`Actual Test Result:` Pass or Fail.

The test plan should be at the bottom of your file in a comment region beginning with a {- line and ending with a -} line. Put your testing code for this assignment in the `Assign_5_Test.hs` file in the `test` folder.