CX 4010 / CSE 6010
Assignment 1
Monte Carlo Integral Computation

Due Dates:

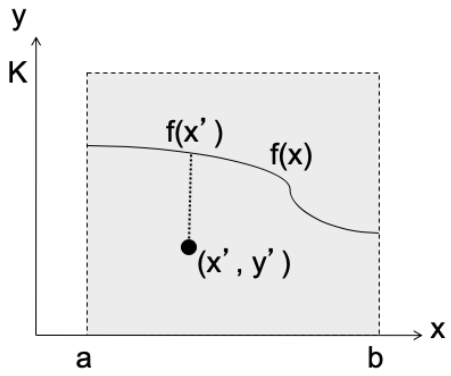
- Due: 11 AM, Friday, August 30, 2019
- No late submissions will be accepted

Write a C program to compute the value of an integral for an arbitrary function $f(x)$:

$$Z = \int_a^b f(x)$$

You may assume *f(x)* is defined and *f(x)≥ 0* for all *x* such that $a \leq x \leq b$. Define a C function to implement $f(x)$. For this assignment assume $f(x) = x^2$ but your code should be written so new functions can be implemented by simply replacing your C function with another.

Use a Monte Carlo simulation approach to compute the value of the integral. The figure below shows a plot of *f(x)* for $x \in [a, b]$. The value of the integral *Z* is the area underneath the curve for *f(x)* for $x \in [a, b]$. Define some constant value *K* such that $K > f(x)$ for all $x \in [a, b]$. Randomly select a point *(x', y')* in the shaded rectangle bound by the X axis, and the lines y=*K*, *x*=*a*, and *x*=*b*. Each point in the shaded box is equally likely to be selected. The probability that the point *(x', y')* lies in the area beneath the curve *y=f(x)* is $\frac{Z}{K*(b-a)}$ because *Z* is the area beneath the curve and *K*(b-a)* is the total area of the rectangle.



Assume *N* random points are selected, and among these *N* points, *n* lie below the line *y=f(x)*. The probability a randomly selected point is below the line is estimated to be $\frac{n}{N}$, or:

$$\frac{n}{N} = \frac{Z}{K(b-a)} \quad \text{or} \quad Z = \frac{nK(b-a)}{N}.$$

Use this formula to estimate the value of the integral *Z*.

You may use the `rand` function from the C standard library. The values for *a* and *b* should be input interactively by the person running the program; you may use the code suggested below to get these values (assuming `a` and `b` have the type `double`):

```
printf("Enter a value for a: ");
scanf("%lf", &a);
printf("Enter a value for b: ");
scanf("%lf", &b);
printf("You entered a=%f and b=%f\n", a, b);
```

Your program needs to come up with a way to select the value of *K*. The program should automatically compute *K* in a way that works for any function *f(x)*, e.g., by probing *f(x)* with various values of *x* and guessing a suitable value of *K* based on the values returned. Use comments in your code to clearly describe how you defined *K*.

Your program should compute and print the estimated value of the integral *Z* for several different values of *N*; each line of the print out should show two values: *N* and the computed estimate of *Z*. One might expect your estimated value of *Z* converges toward the correct answer as *N* increases to infinity.

Turn in (1) your code, (2) a README file that includes instructions how to compile and run the program, and (3) a brief statement explaining why you believe your program works correctly, e.g., by showing the output of a sample run and compare the computed result with the correct value.

Your code must be well structured and documented to receive full credit. Be sure to include comments to describe your approach to defining the value *K* used by your program. Your code should check for incorrect values (*a*, *b*, and *K*) and take appropriate action if an error is detected.

Note that for some functions *f(x)* is undefined for certain values of *x* in *[a,b]* and it will be impossible to define a suitable value for *K*. For example, consider *f(x)=1/x* and 0 lies in *[a,b]*. Your program should do "something reasonable" to handle cases like this.

Collaboration, Citing, and Honor Code

As a reminder, please refer to the course syllabus regarding rules and expectations regarding collaborating with other students and use of other resources, including materials available on the web.