COMP605/CS605: Scientific Computing, Spring 2023
Assignment 2 - Due Tuesday 3/14/23

Under your home directory create a directory assign2.
Then cd assign2 and create two directories: MonteCarlo and Trapezoidal.

1. (30 points) Suppose we toss darts randomly at a square dartboard, whose bullseye is at the origin, and whose sides are two feet in length. Suppose also that there is a circle inscribed in the dartboard. The radius of the circle is one foot, and its area is π square feet. If the points that are hit by the dart are uniformly distributed (and one always hit the square), then the number of darts that hit inside the circle should approximately satisfy the equation

$$\frac{\text{number in circle}}{\text{total number of tosses}} = \frac{\pi}{4},$$

since the ratio of the area of the circle to the area of the square is $\frac{\pi}{4}$.

One can use this formula to estimate the value of π with a random number generator.

```
number_in_circle = 0;

for (toss = 0; toss < number_of_tosses; toss++)
{
    x = random double between -1 and 1;
    y = random double between -1 and 1;
    distance_squared = x*x + y*y;
    if (distance_squared <= 1) number_in_circle++;
}

pi_estimate = 4* number_in_circle/((double) number_of_tosses);
```

This is called Monte Carlo method since it uses randomness (the dart tosses).

Write a Pthreads program that uses Monte Carlo method to estimate π. The main thread should read the total number of tosses and print the estimate. You may want to use *long long int*s for the number of hits in the circle and the number of tosses, since both may be to be very large to get a reasonable estimate for π.

Under MonteCarlo, create a parallel C program named MonteCarlo.c (that receives the number of threads in the command line) and an executable named MonteCarlo.

2. (70 points) Use the Trapezoidal rule

$$\int_a^b f(x)\,dx \approx \frac{b-a}{n}\left(\frac{f(a)}{2} + \sum_{k=1}^{n-1}\left[f\left(a + k\,\frac{b-a}{n}\right)\right] + \frac{f(b)}{2}\right),$$

to compute an approximation of the integral of $f(x)$ on $[a, b]$.

Write a Pthreads program that uses the Trapezoidal rule to estimate $\int_a^b f(x)\,dx$ for $a = 1$, $b = e^4$, $f(x) = \ln(x)$, $n = 1024$.

Use a shared variable for the sum of all threads' computations.

(a) Use busy-waiting, mutexes, and semaphores to enforce mutual exclusion in the critical section.

(b) What advantages and disadvantages do you see with each approach?

Under Trapezoidal, create a C program named Trapezoidal.c (that receives the number of threads in the command line) and an executable named Trapezoidal.