# **Physics 4610 Computational Physics I**

Fall 2009

*Dr. Kamran Sahami*

Since this is the first class project we should discuss some of the expectations for completion. For all projects you will turn in your code and several samples of the output of that code. You will often be asked to make several different calculations with the same piece of code so comment out the lines for the parts not being used or better yet use a flag system to turn on and off the portions for each section. In general I will ask you to graph the output and offer some analysis of the results. There will also be specific questions (often out of your textbook) to be answered as part of each exercise in the project.

## Project # 1 Monte Carlo Integration

Due 9/14/2009

Download the Project # 1 PDF files from the class webpage:
http://www.mscd.edu/~physics/sahami/4610.html

They include sections 7.0 & 7.1 of Numerical Recipes in FORTRAN (NRinF) on random numbers and section 7.6 on Simple Monte Carlo Integration. These sections include several excellent examples, as well as some sample code. There is also a research paper (rand2006.pdf) about MATLAB's random number generator and some of its built in functions. We will discuss the details of random number generator quality in class. I have also placed 2 papers on the Mersenne Twister (MT) algorithm for improved random numbers. One is the extended Wikipedia article on the MT and the other is Matsumoto and Nishimura's original 26 page paper on the algorithm in case you are interested.

### Exercise 1. (30 points) Determining $\pi$

1.a Write a MCI routine to determine the value of $\pi$. How might $\pi$ be found from a simple integration?

1.b Use your language's simple random number generator and note the seed value. Make a graph of the value of $\pi$ as a function of the number of random numbers generated. How many random numbers do you need to generate to get $\pi$ accurate to 3 digits (3.14)? 5 digits (3.1416)?

1.c Repeat you calculations using the Mersenne Twister algorithm or one of the "enhanced" random number generator algorithms from NRinF.

Exercise 2. (70 points) 3D Integration

Section 7.6 of NRinF discusses the mass integration of a torus section in 3 dimensions and then looks at the same integration for a variable density function.

2.a Write an MCI routine using your better random number generator algorithm from section 1.c to find the mass of an ellipsoid given by:

$2x^2 + 3y^2 + z^2 = 25 \quad \text{with } \rho = 1.000 \frac{kg}{m^3}$

what is the analytic solution? How close can you get with a reasonable[1] number of random numbers?

2.b Repeat the calculation above for the ellipsoid in 2.a but now truncated by :

$z = \pm 2$ and $x = -1$

Compare a reasonable run to the analytic solution.

2.c Repeat the calculation in 2.b but for $\rho = x^2 \frac{kg}{m^3}$ and compare this to the analytic solution. How does this compare?

2.d Give an example of this type of calculation in which the analytic solution would be far to difficult if not impossible to attempt.

[1] reasonable- is a strong function of your computer's speed and the efficiency and quality of your code. In this example I would consider calculations taking on the order of 30 minutes to run to be "reasonable". Therefore this definition of "reasonableness" changes with time :)