Physics 441 Assignments – Part Two

9. Wilberforce Pendulum

Based on the program that I am providing for solving the orbits of comets, make modifications to solve the Wilberforce pendulum using the RK4 algorithm (4th Order Runge-Kutta). Use the following parameters:

Initial z displacement = 0.10 m, and initial theta=0

m = 0.5164

k= 2.80

delta = 0.000786

epsilon = 0.00927

Determine the value of I necessary to optimize the oscillation between the two normal modes (i.e. omega\_z = omega\_theta). Produce of plot of theta vs. time for several beats of the pendulum coupling.

You may find the following link useful:

http://faraday.physics.utoronto.ca/PHY182S/WilberforceRefBerg2of8.pdf

10. Random Number Generation

Write a program that generates and plots the following random number distributions:

1. A uniform distribution on the interval [0,1]
2. A triangular distribution on the interval [0,2]
3. A decaying exponential distribution with a decay constant of 1
4. A Gaussian distribution with a mean of zero and a sigma of 1
5. A Gaussian distribution with a mean of 1 and sigma of 0.3

Final Project: Kinetic Theory of Gases Simulation

Beginning with the “raw” C++ codes provided for this simulation, complete the following:

1. Create a ROOT macro to run the simulation and produce histograms of the intitial and final velocity distributions. This includes making the following changes:
2. Replacing the rand() random number generator with ROOT’s TRandom3 Mersenne Twister class.
3. Replacing the hand-rolled Matrix class with ROOT’s TMatrixD class (thus removing the dependence on Matrix.h)
4. Removing the dependence on NumMeth.h
5. Produce a plot of the equilibrium velocity distribution for Argon gas at standard temperature and pressure assuming a uniform initial velocity (v = ). Compare the mean and RMS width of this distribution to what one would expect from the Maxwell-Boltzmann distribution.
6. Fit the distribution from part (a) with a Maxwell-Distribution function. Clearly, this is a non-linear fit, and so you may find it useful to use the code that you wrote for the non-linear fitting assignment(s) for this purpose.
7. Produce a plot of the mean equilibrium velocity for Argon gas from T=20K to T=300K in steps of 20K. How does the temperature dependence compare to what is predicted by theory?
8. Use the TStopwatch class in ROOT to allow the measurement of the time taken in each of the colider and sorter methods, as well as the total time taken.
9. Determine and plot the appropriate number of time steps to reach thermal equilibrium as a function of (i) the initial number of particles and (ii) the initial temperature.
10. Create plots of the total, colider, and sorter times as a function of the number of particles in the simulation. Assume T=273K. Use the appropriate number of timesteps to reach thermal equilibrium, as determined in part (f).