Assignment 2 Handout

Simulation and Modeling (CSCI 3010U)

Faisal Qureshi

Due back on Nov. 7, 11:59 pm

Question 1 [10 marks]

Consider a rigid body composed of n point masses m_i, where $i \in [1, n]$. Assume that this rigid body is under the influence of a uniform force field, such as gravity. Gravity exerts a force mg in the downward direction at each point mass. Compute the net force acting on this body due to gravity. Also compute the net torque acting on this body.

Question 2 [4 marks]

Why do we care about random numbers? Why is there such an interest in *pseudo-random* numbers?

Question 3 [26 marks]

Simulate a system comprising 10 disks moving in a closed environment. It is a 2D square room. The room is 5 meters wide and 5 meters high. You will need to handle collisions between the disks and the 4 walls. You are also asked to model inter-disk collisions. You may assume that more than two disks never hit each other simultaneously. In order to run this simulation you need to initialize this system as follows:

1. Assign random positions and velocities to the disks. The positions are bounded by the size of the room. The velocity magnitude for each disk is bounded by 0 and 10. Randomly assign a velocity to a disk. Ensure that the velocity magnitude for each disk is more than 0 and no greater than 10.
2. You will also need to assign masses to each disk. Assume that the mass for a disk is between 1 and 5 kg. Assign random masses to the disks
3. Assume *coefficient of restitution* $e = 1$.
4. Lastly you need to assign a radius to each disk. The radius of a disk is between 0.1 and 0.2. Assign a random radius to each disk.

You are also required to submit a one page brief outlining your algorithm.

Question 4 [50 marks]

In this part of the assignment you will produce a simulation of a leaf blowing in the wind. The leaf starts at a height h above the ground and it has probabilities 0.1, 0.55, 0.15, and 0.15 of moving up, down, left or right at each step of the simulation. The probability of staying at its present location is 0.05. This simulation must be run a large number of times in order to gather meaningful statistics. How do you know that your simulation is correct?

1. Record the time t for the leaf to reach the ground in each simulation. Construct a histogram from these values and compute the value of the mean and variance of t. How do these values vary with the value of h?
2. Consider the horizontal displacement x of the location where the leaf lands on the ground. Construct a histogram of this value and determine how the variance in x(horizontal position of droplet) depends upon h.

c. In the current simulation the probabilities of moving left and right are the same. Change these probabilities so the leaf has a higher probability of moving left than right. What impact does this have on your results?

70% of the overall marks for this question is based upon your analysis of the problem at hand (i.e., the written report). Be as rigorous as possible. *You must have run the simulations a large number of times to have gathered meaningful statistics.* Your written report should include a summary of all the tests that you conducted, plots of statistics that you gathered, and your analysis and a discussion of the statistics. The remaining 30% will be determined by how user-friendly (and correct) your program is, i.e., does it allow user to specify different parameters, can it gather statistics automatically and plot them as histograms, etc.

Submission

Submit the following files via Blackboard

- lastname-a2-q1-q4.pdf (*contains written portion of the solutions to all questions*)
- lastname-a2-q3.py
- lastname-a2-q4.py