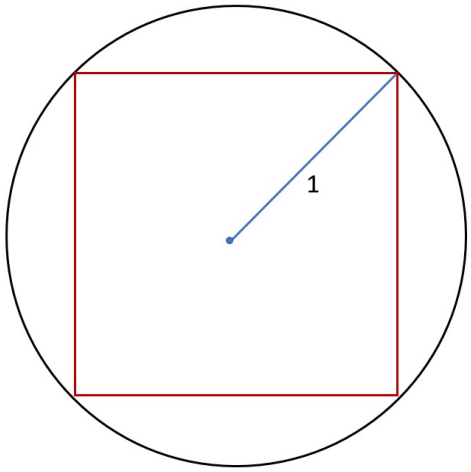
End Semester Exam Paper: IE 601

May 14, 2021

Instruction: Keep all the files (the program files and all the figure files) in a folder and convert the folder to a zip file with a name following the format "*yourname_rollnumber*". For example, if a student's name is "Rahul" and the roll number is "1111111", then the name of the zip file would be "*Rahul_*1111111". After you generated the zip file of your answer paper please submit the file in google classroom (IE 601). You need to submit the answer paper by the end of tonight, i.e. 11:59 pm, 14th May, 2021. Total Marks of the question paper is 60.

1. Consider the following figure where the value of the radius of the circle is 1. Write a frotran code where you throw 1 lakh random points equally distributed inside the circle. Based on the fraction of points fall inside the square calculate the value of π as a function of the number of points you have thrown. Plot the value of π versus the number of random points. [Hint: Consider polar coordinate]. **[Marks=10]**



2. Obtain a set of random numbers with the following distributions from 1 Lakh random numbers generated from in-built random number generator subroutine encoded in fortran.
   i. Distribution following exp(-5x), where x is random number. Plot the probability distribution of the random numbers as a function of the value of the random number. **[Marks=5]**
   ii. Distribution following $exp(-(x-0.5)^2/0.05)$. Plot the probability distribution of the random numbers as a function of the value of the random number. **[Marks=5]**

3. Consider a 2D square lattice of size 10×10. Let us consider there is a magnetic spin at each lattice site with the spin value either +1 or -1. Starting with an initial configuration with all the spins up (+1), run Monte Carlo (MC) simulations at various temperatures (T = 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4). Plot average magnetic moment versus temperature. The length of the MC simulation at each temperature should be 1 Lakh MC steps where 1 MC step is equal to the $10 \times 10 = 100$ attempts to flip the spins. The total energy of the system is $E = \sum_{i,j} \sigma_i \sigma_j$

where i and j are nearest neighbors. σ_i and σ_j are the spin values of the magnetic spins at the lattice sites i and j, respectively.. **[Marks=20]**

4. Solve the harmonic oscillator problem, F=-kx, numerically and plot the position, velocity, kinetic energy and potential energy as a function of time using:
   i) Euler's method. **[Marks=5]**
   ii) Verlet Algorithm. **[Marks=5]**
   iii) Leapfrog Algorithm. **[Marks=5]**
   iv) Compare the three cases and draw the conclusions. **[Marks=5]**