CHEM/PHY 598

Warm-up Pset

Info: You can work in groups, but all solutions must be written up independently. Many of the written problems –which are not assigned directly from the class textbook– are taken from a variety of other textbooks/papers. If any question requires a computational component, provide your written answer on one sheet, then the printout of your Mathematica notebook only for that problem on separate sheets following your write-up for that problem. Then repeat for each problem. i.e. do **not** staple a Mathematica notebook printout for all problems at the end of your problem set. **Only codes that are commented *at every step* and *whose logic can be easily followed* will be graded**.

DUE: Tuesday February 9th, 3PM. To be handed in within the first five minutes of class.

Problem 1: Simulating stochastic processes

Imagine a process with an exponential waiting time between events as we have seen in class. We call this a birth process.

a) Use the cdf of the exponential distribution to derive an expression for how to sample from an exponential distribution.

b) Sample 100 exponential time intervals (you need to specify a rate, λ, by hand). Use your generated data to construct the normalized cdf and pdf (you can choose arbitrary bins for the pdf histogram).

c) Estimate the rate, λ, from the mean of the exponential time of arrivals. Then estimate the mean by fitting the cdf and pdf (use whichever criterion you like, like minimizing R^2 on Mathematica, to find the closest λ). Which method for estimating λ seems more efficient?

Problem 2: Poisson processes

a) Devise a sampling scheme to sample from the Poisson distribution and code it up (i.e. don't use the built in package from Mathematica).

b) Generate 1000 Poisson random variables from the Poisson distribution. Compute the ratio of mean and variance after every random variable is collected (i.e., using only the first and second data points; then using the first, second and third, etc...). Plot this ratio from 2 to 1000 (where, just to be clear, for 1000 you would be using all data points to compute the mean and variance). To what value does this ratio converge?

Problem 3: Birth-death process

RNA is produced from DNA. RNA can also be degraded. Simulate this birth-death process for RNA (assuming a birth rate greater than the death rate). Plot the amount of RNA as a function of time until the value reaches steady state. How is this steady state related to the birth and death rate?