ChE-304 Problem Set 8

Week 9

Problem 1

You want to determine the distribution of corn yields across farms for biofuel production using a Monte Carlo analysis. There are two sources of variation for crop yields from year to year. First, the amount of fertilizer varies, which causes the yield to vary but this yield can also be influenced by random growth factors. The yield is calculated as:

$Yield = F \times a$

where F is the amount of feritlizer used (in kg/acre) and a is a growth parameter (in ton corn per kg fertilizer used).

Both the amount of fertilizer yield and the growth parameter vary according to a Cauchy distribution:

Probability distribution function:

$$P(z; z_0, \gamma) = \frac{1}{\pi \gamma} \left[\frac{\gamma^2}{(z-z_0)^2 + \gamma^2} \right]$$

Cumulative distribution function:

$$CDF(z; z_0, \gamma) = \frac{1}{\pi} \arctan \left[\frac{(z-z_0)}{\gamma} \right] + \frac{1}{2}$$

Where:

z_0: is the average value of z
γ: is the half width at half maximum of the distribution (sort of like a standard deviation for a normal distribution.

Here:
$z_{0,F} = 1 \, kg/acre$ $z_{0,a} = 5 \, ton \, corn/kg$
$\gamma_F = 0.1 \, kg/acre$ $\gamma_a = 1 \, ton \, corn/kg$

Use a 6-faced dice as a random number generator and plot the final distribution function. I have prepared a template to bin your results.

Hint: divide the dice result by 7 in order to always obtain a number between 0 and 1. I recommend performing at least 20 dice rolls for each parameter to get a decent result…

Problem 2

Someone proposes you a PV system that has a lifetime of 20 years for your house at a price of 25'000 CHF with the promise that you can continuously sell electricity at a garanteed cost that will bring 3'000 CHF in lump sum payment at the end of each year (in today's CHF).

To finance it, you could borrow money at 2% a year from a bank. What is the net present value of you investment given this cost of money (2%)?

Can you calculate the actual discounted rate of return of the PV investement (this might require some iteration)?

Finally, assuming you actually had 25'000 CHF in your bank account. Should you invest in these solar panels or in the stock market, where you can likely get a return of about 5-6%?

Problem 3

A nuclear power plant must provide enough money to decommission its setup at the end of its 30 year lifetime. The cost (in today's dollars, i.e. corrected for inflation) is 300 million dollars.

Assuming it uses a fund that has a real interest rate (inflation free) of 5% a year (compounds continuously), how much must the power plant owners put aside every year?

How much would they need to put aside if a lump payment at the installation of the plant was required?