### Problem Set 3

Total 15 points

Due Monday, 13 February 2023 before 11:59pm

*Instructions: This is a GROUP assignment.*

I think it makes sense to submit an excel spreadsheet if you work with excel/VBA, a word document or notebook with embedded figures if you use R/Python.

*(a) Only submit one assignment per group but make it very clear who the group members are.*

*(b) The file name should be: PSn.FAMILYNAME1Initial1\_FAMILYNAME2Initial2….xls,*

*for example my solution to Problem set 1 would have the file name PS1.WIDDICKSM.xls.*

*(c) Please make sure that your solutions are well-organized and clear, with appropriate text, explanations, and formatting. If I cannot figure out what you did, then what you did is wrong.*

**Practice with the Binomial spreadsheet (7.5 points)**

Adapt the trees from ImpBinomial.xls to value a slightly simplified version of this product for Caterpillar (CAT). Alternatively, adapt the python code that also values a 50 step tree to perform the same valuation

[Term Sheet Here](https://www.sec.gov/Archives/edgar/data/1114446/000183988222028844/ubs2000086635_424b2-14255.htm)

I have tried to match the r, d, and s as closely as possible (saving you time this time here) you are welcome to try to obtain this data yourself (especially the dividend history)

Face value: $1000

Payoff at maturity: if the stock price is greater than or equal to $193.20 then you receive the face value plus the final coupon payment. If the stock price is below $193.20 you receive a cash amount equivalent to 1000/193.20 = 5.1761 stocks plus the final coupon payment.

Autocall feature: If the stock price is greater than or equal to the initial price ($227.29) on any of the observation dates t = 1/4, 1/2, 3/4 then the notes are immediately called for the face value + coupon.

Coupons: there is a monthly coupon of 11.85% (this is an annual figure) of the face value, payable at t = 1/12, 2/12 etc.

To set up your tree choose:

N = 100 (i.e twice the size of the ones in class)

S0 = 227.29

T = 1 (or you can be more precise T = 367/365)

r = 4.8%

s = 35.73%

Proportional Dividends: 2.19% (annual figure) quarterly on Jan 19, 2023, Apr 24, 2023, July 18, 2023, and Oct 20, 2023. You can approximate these but make sure they are roughly correct relative to the autocall observation dates (Mar 9, Jun 9, Sep 11)

Use the same u, d formulas as given in the spreadsheet/python code in Lecture 3 (obviously adjusting for s).

**First real coding exercise – analysis of European option prices [7.5 points]**

Consider a European put option where S0 = 100, K = 105, r = 0.04, d = 0, s = 0.3 and T = 0.5.

1. Calculate the value of the European put options using the Black-Scholes formula.

We will now compare the performance of the following binomial lattice methods.

* Cox, Ross and Rubinstein, 1979 (*u = e√t*, *d = 1/u*)
* Rendleman and Bartter, 1979 (*u =* exp*((r--0.52)t+√t)*, *d =* exp*((r-0.52)t-√t)*)
* Leisen and Reimer, 1996 (see Lecture 4 notes)

**For each model perform the following:**

1. Calculate the value of the European put option for time steps ranging from N = 50 to N = 1000.
2. Plot a graph of N (x-axis) against error (y-axis) when compared to the Black-Scholes price.
3. Explain the graphs you obtain in c.