Numerical Methods II
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Practical 4

1. Based on the first half of `lec9_weak.m` write a code to use the Euler-Maruyama method and the Likelihood Ratio Method to estimate Vega for a European call option based on the usual Geometric Brownian Motion SDE:
$$\mathrm{d}S = r\,S\,\mathrm{d}t + \sigma\,S\,\mathrm{d}W.$$
Use 64 timesteps and the same parameters as in `lec9_weak.m` (i.e. $r=0.05, \sigma=0.5, T=1, S_0=100, K=110$).

   Check that you get the correct answer by comparing to the analytic solution given by `european_call.m`.

2. Repeat the previous question but this time using the pathwise sensitivity approach.

3. Modify your code for the previous question to compute the Vega for the down-and-out call option you considered in Problem Sheet 3, question 4, using parameter values $r=0.05, \sigma=0.5, T=1, S_0=100, K=110, B=90$.

4. Download the code `sobol_basket.m` which is available on the course webpage.

   This computes the values for three different basket options based on 5 underlying assets (European call, Asian call, lookback call) using either a standard Monte Carlo method or QMC with Sobol points, with or without Brownian Bridge in time, and with or without PCA for the correlation between the 5 driving Brownian motions.

   Run it to see the results, and note that the QMC with Brownian Bridge and PCA gives the smallest standard deviation. Then read it through carefully and try to understand each step of the program. Ask questions if anything is not clear.

   The code currently uses a total of $2^{15} = 32768$ samples, divided into 32 "families" of 1024 points, with each family using a different randomisation.

   Extend the code to vary the number of points N within each family, but keeping 32 families for the randomisation, and generate 3 plots, one for each option type, showing how the standard deviation varies with N for the Sobol with BB, Sobol without BB and plain MC, using the PCA correlation factorisation for all three.