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Roll Number: 180123063
Dept.: Mathematics and Computing

Q1.

With the initial values and the definitions for up-down factors (as given in the assignment), the value of the Initial Option Prices are as follows:

$$S(0) = 100; K = 100; T = 1; M = 100; r = 8\%; \sigma = 20\%.$$

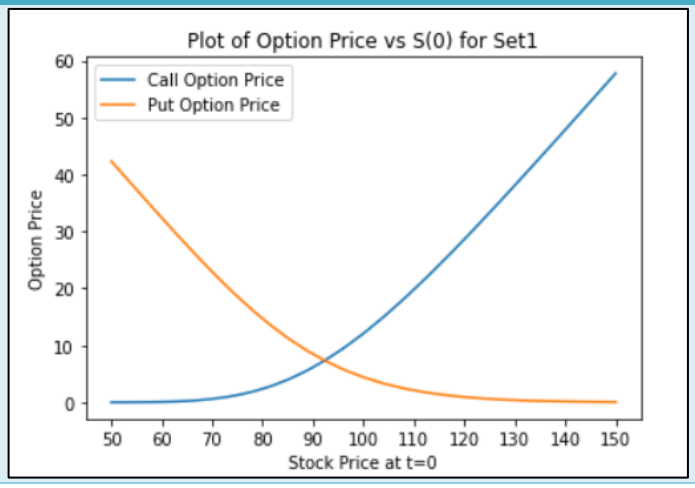
$$\text{Set 1} : u = e^{\sigma\sqrt{\Delta t}} \; ; \; d = e^{-\sigma\sqrt{\Delta t}}.$$

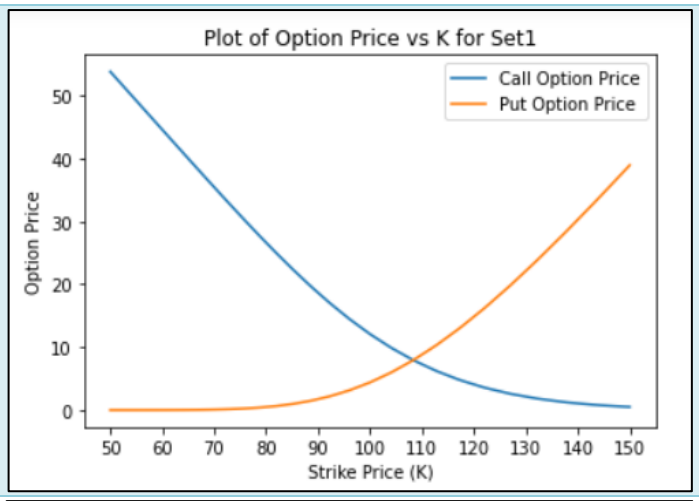
$$\text{Set 2} : u = e^{\sigma\sqrt{\Delta t}+\left(r-\frac{1}{2}\sigma^2\right)\Delta t} \; ; \; d = e^{-\sigma\sqrt{\Delta t}+\left(r-\frac{1}{2}\sigma^2\right)\Delta t}$$

```
For Set-1
European Call Option Price = 12.08538001
European Put Option Price = 4.39701465
For Set-2
European Call Option Price = 12.12304707
European Put Option Price = 4.43468171
```

The graph of the initial option prices was observed by varying a single parameter (2-D Plots) and two parameters (3-D Plots). All possible combinations have been explored. In most of the cases, Put and Call option prices have been plotted in the same graph for better comparisons.

Set 1	Set 2

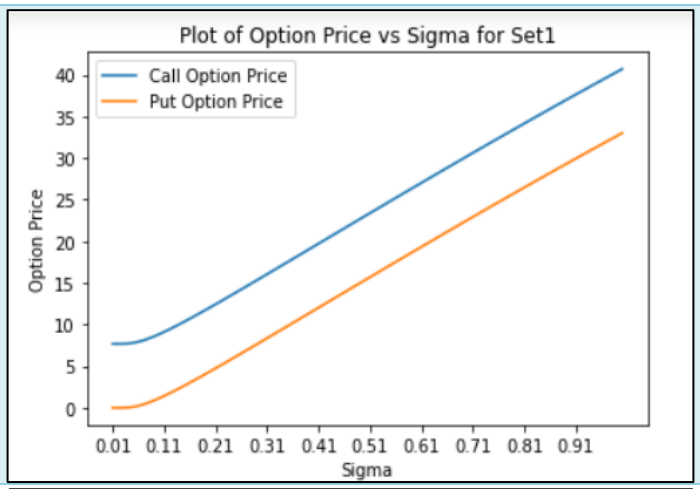



Plot of Option Price vs K for Set1
Call Option Price
Put Option Price
Option Price
Strike Price (K)

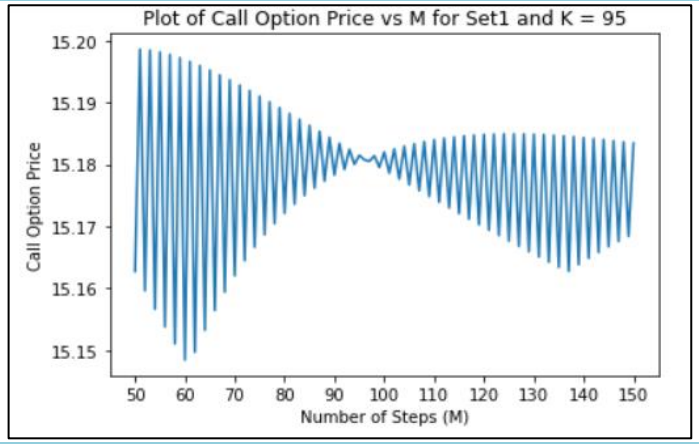

Plot of Option Price vs K for Set2
Call Option Price
Put Option Price
Option Price
Strike Price (K)

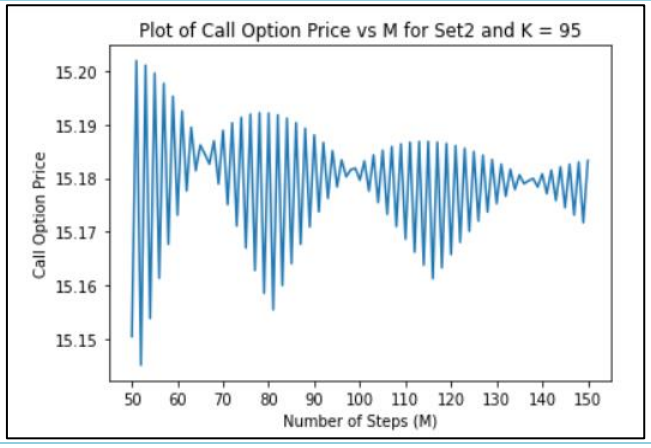

Plot of Option Price vs Interest Rate (r) for Set1
Call Option Price
Put Option Price
Interest Rate (r)

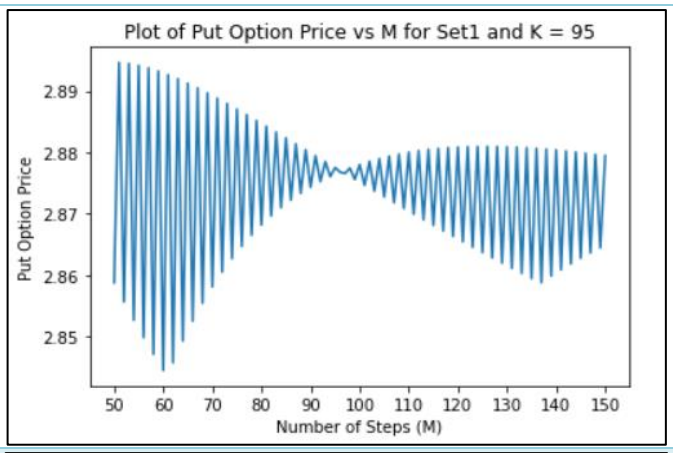

Plot of Option Price vs Interest Rate (r) for Set2
Call Option Price
Put Option Price
Option Price
Interest Rate (r)


Plot of Option Price vs Sigma for Set1
Call Option Price
Put Option Price
Option Price
Sigma

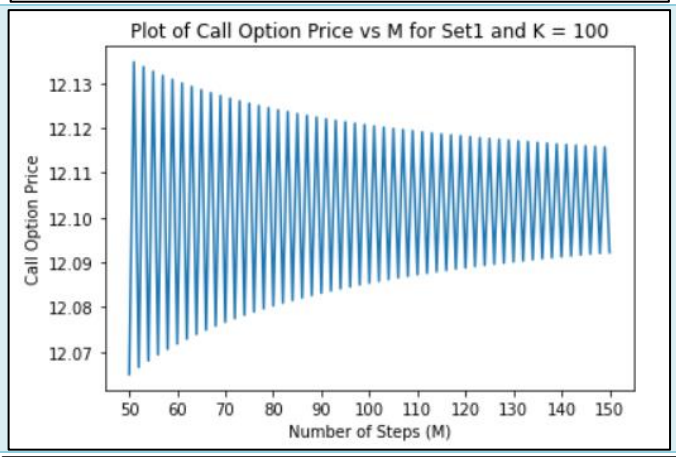

Plot of Option Price vs Sigma for Set2
Call Option Price
Put Option Price
Option Price
Sigma

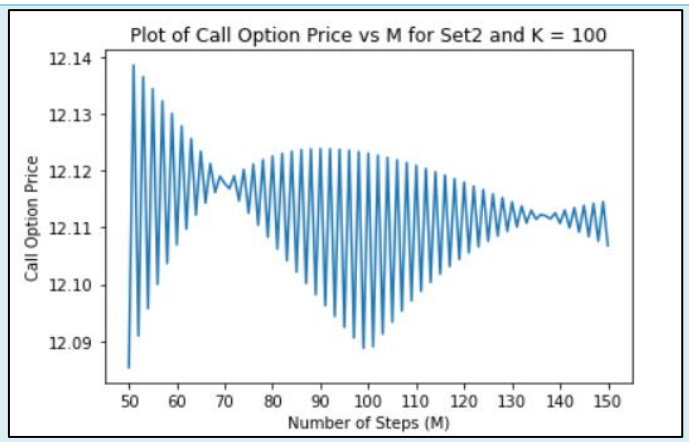

Plot of Call Option Price vs M for Set1 and K = 95
Call Option Price
Number of Steps (M)

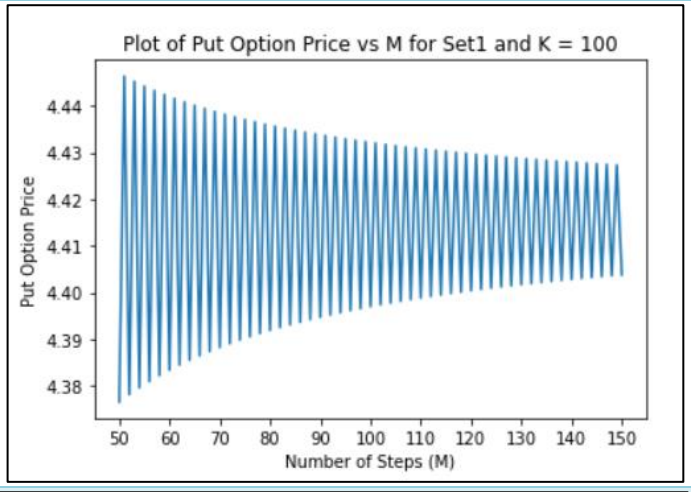

Plot of Call Option Price vs M for Set2 and K = 95
Call Option Price
Number of Steps (M)

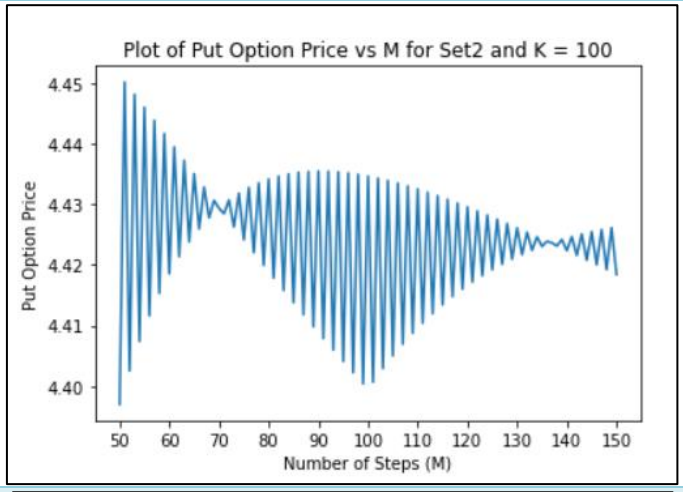

Plot of Put Option Price vs M for Set1 and K = 95
Put Option Price
Number of Steps (M)

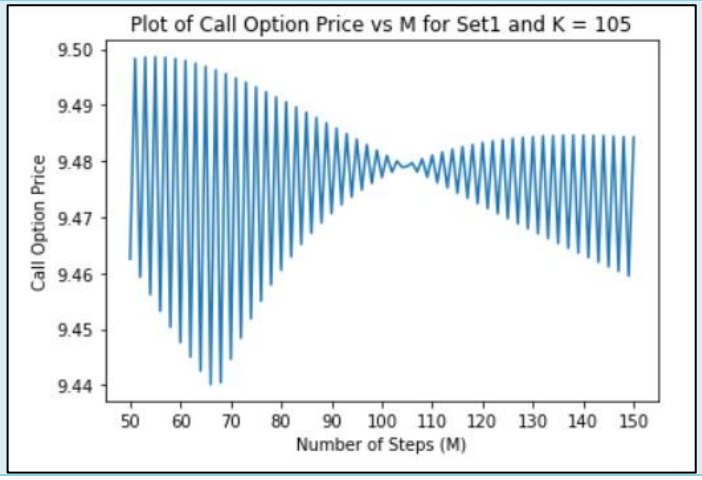

Plot of Put Option Price vs M for Set2 and K = 95
Put Option Price
Number of Steps (M)

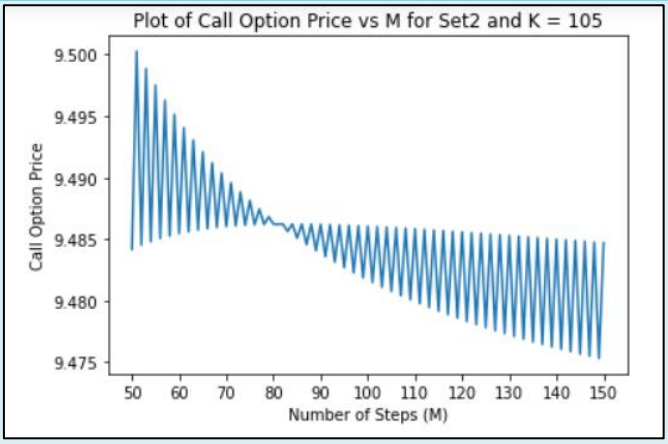

Plot of Call Option Price vs M for Set1 and K = 100
Call Option Price
Number of Steps (M)

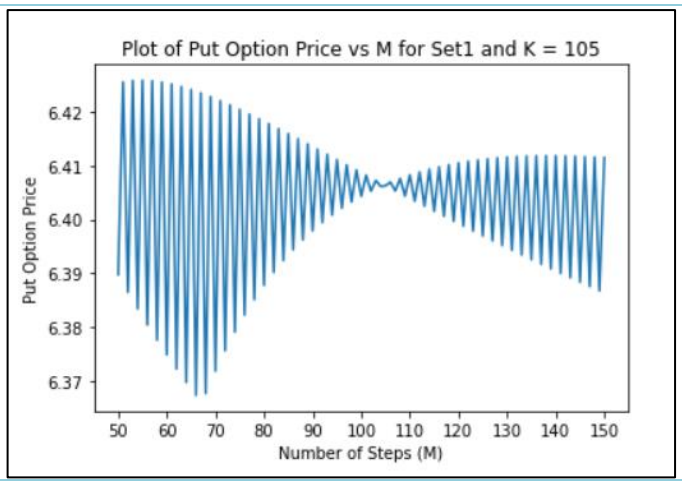

Plot of Call Option Price vs M for Set2 and K = 100
Call Option Price
Number of Steps (M)

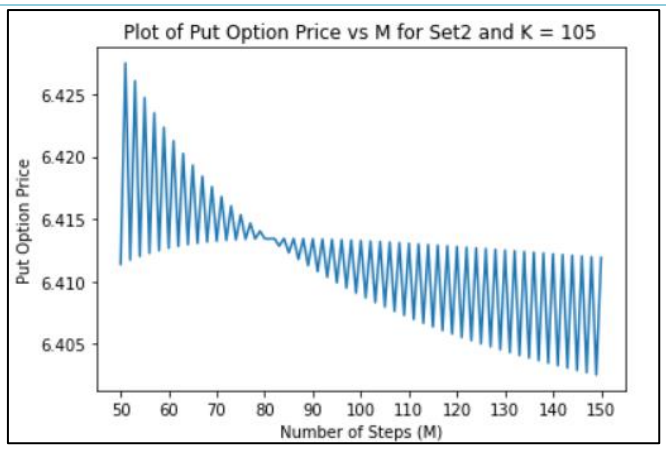

Plot of Put Option Price vs M for Set1 and K = 100
Put Option Price
Number of Steps (M)


Plot of Put Option Price vs M for Set2 and K = 100
Put Option Price
Number of Steps (M)


Plot of Call Option Price vs M for Set1 and K = 105
Call Option Price
Number of Steps (M)


Plot of Call Option Price vs M for Set2 and K = 105
Call Option Price
Number of Steps (M)

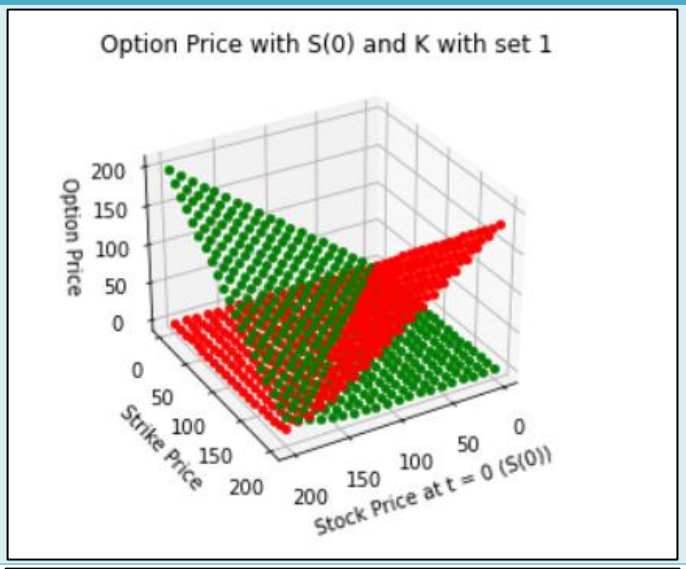
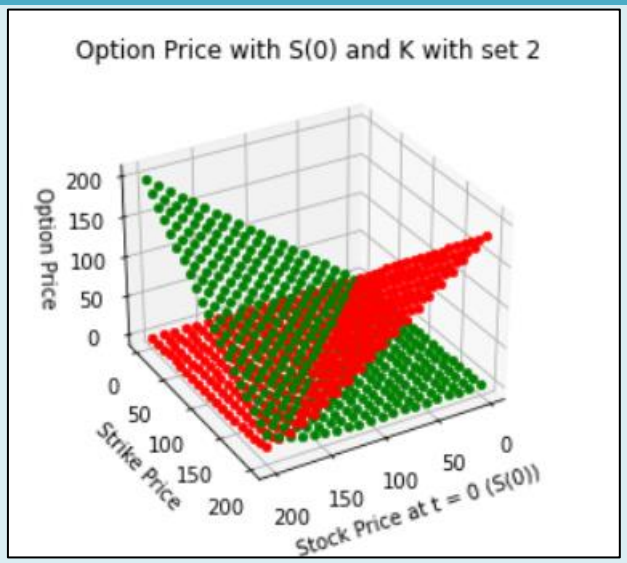
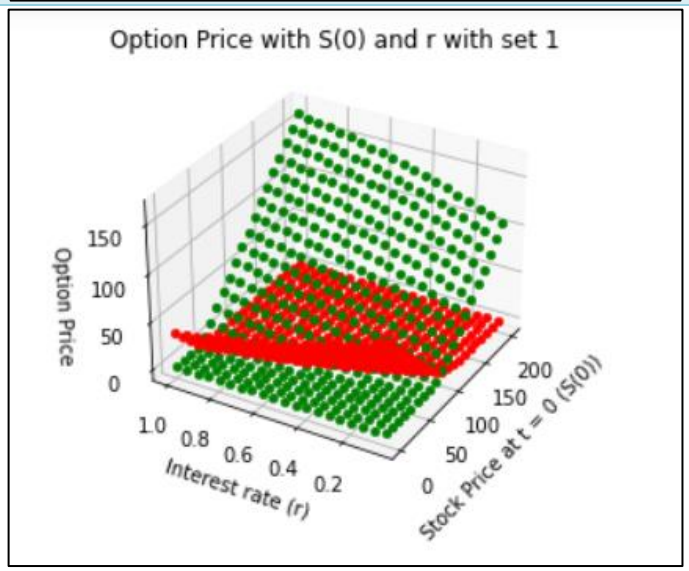




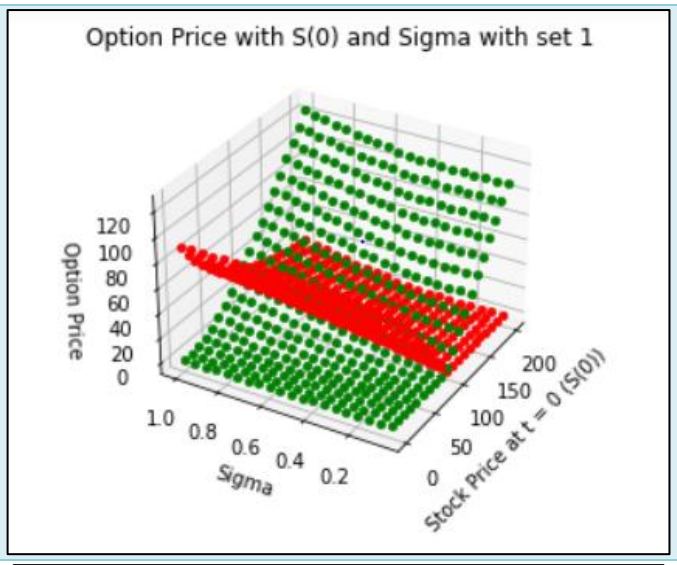
3-D Plots: (varying two parameters at a time)

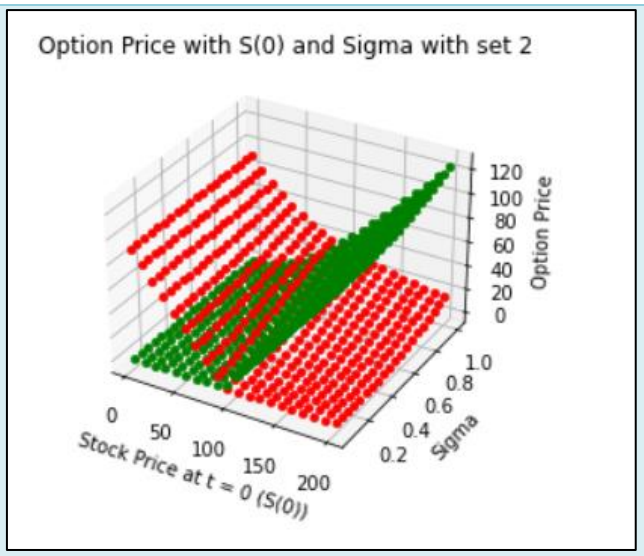
Green represents European Call Option Price

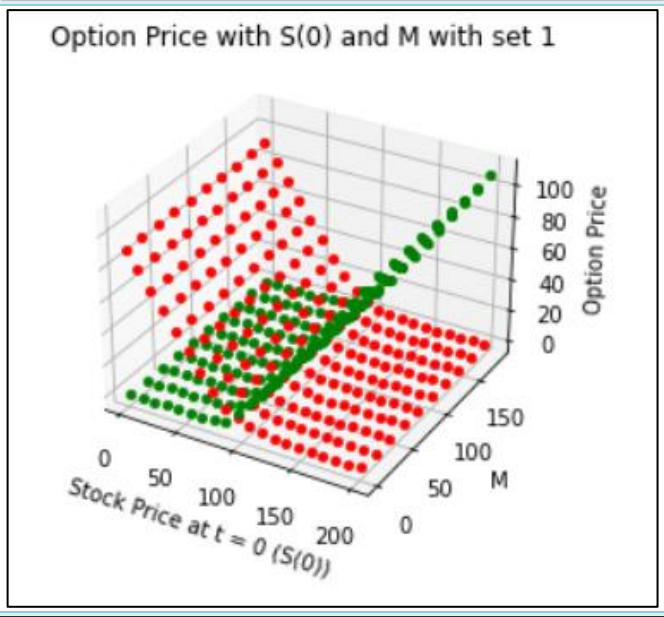
Red Represents European Put Option Price

Set 1	Set 2
	
	

Option Price with S(0) and Sigma with set 1


Option Price with S(0) and Sigma with set 1
Option Price
Sigma
Stock Price at t = 0 (S(0))


Option Price with S(0) and Sigma with set 2
Option Price
Sigma
Stock Price at t = 0 (S(0))

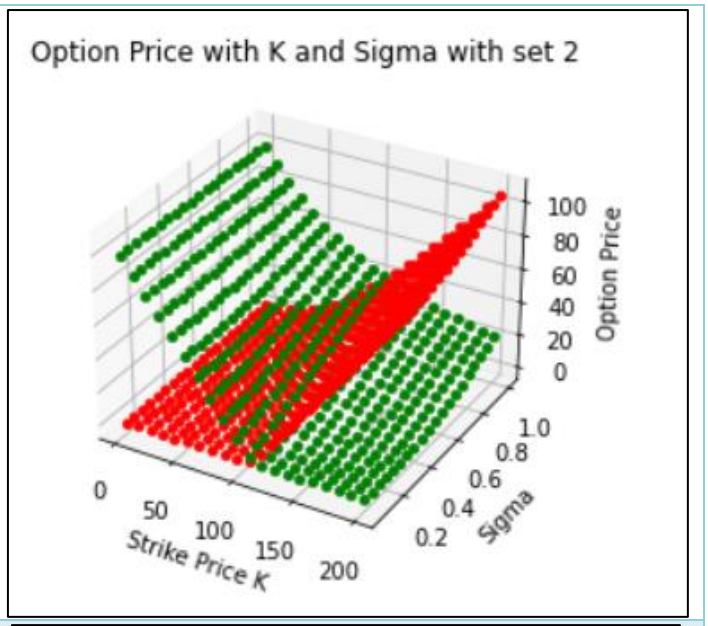

Option Price with S(0) and M with set 1
Option Price
M
Stock Price at t = 0 (S(0))

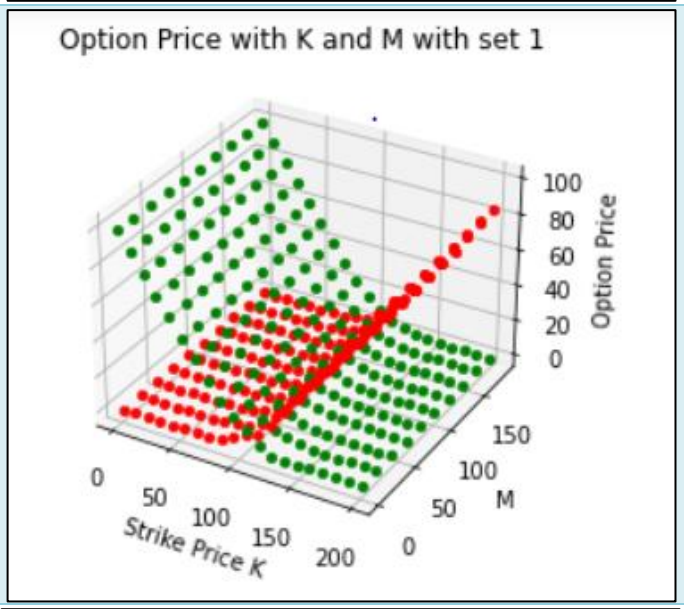

Option Price with S(0) and M with set 2
Option Price
M
Stock Price at t = 0 (S(0))
Option Price with K and r with set 1


Option Price with K and r with set 1
Option Price
Interest Rate (r)
Strike Price K


Option Price with K and r with set 2
Option Price
Interest Rate (r)
Strike Price K


Option Price with K and Sigma with set 1
Option Price
Strike Price K
Sigma

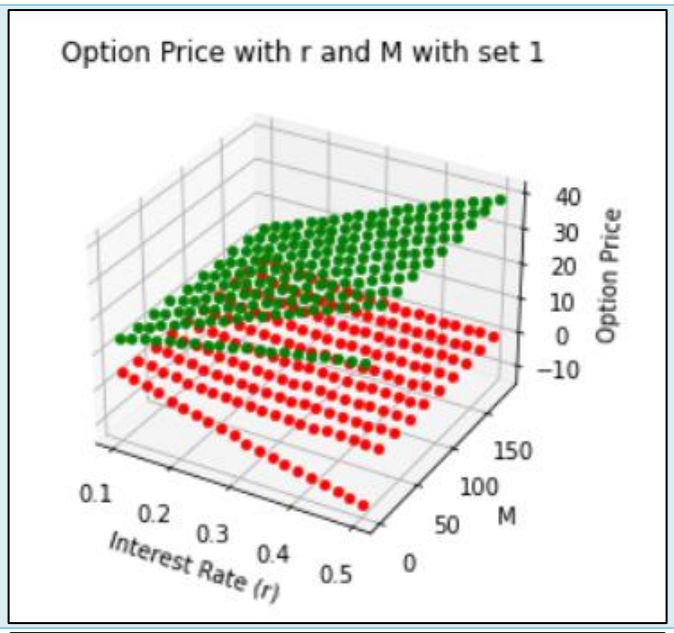

Option Price with K and Sigma with set 2
Option Price
Strike Price K
Sigma

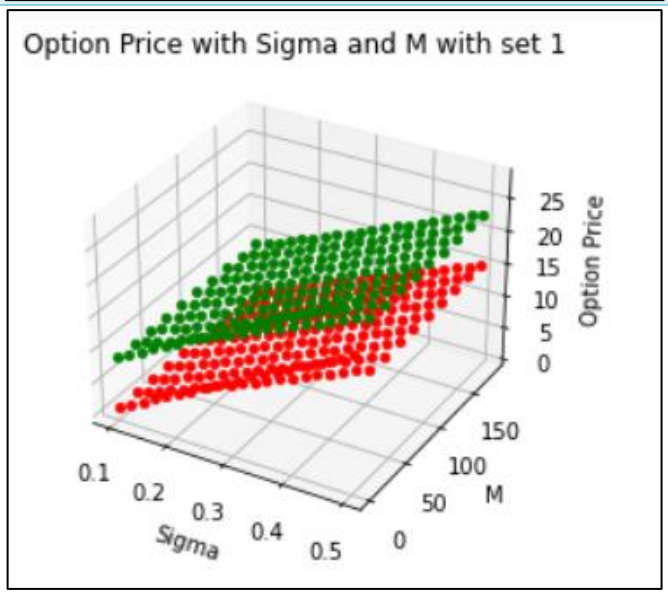

Option Price with K and M with set 1
Option Price
Strike Price K
M

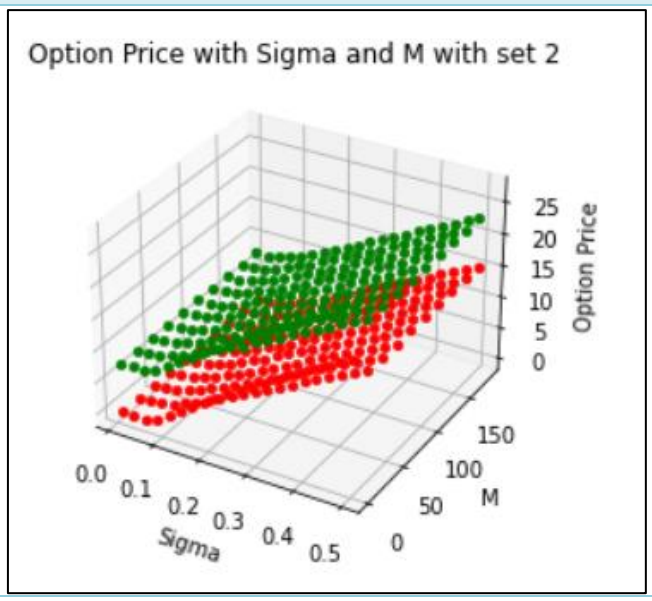

Option Price with K and M with set 2
Option Price
Strike Price K
M


Option Price with r and sigma with set 1
Option Price
Interest Rate (r)
Sigma


Option Price with r and sigma with set 2
Option Price
Interest Rate (r)
Sigma







Q2.

Here, the path dependent derivative used is **Asian Option**.

The initial Asian option price was calculated as follows:

$$H(0) = \frac{1}{e^{rT}} \sum_{over\ all\ paths} p^{ups}(1-p)^{M-ups} f(S_{avg})$$

$\boldsymbol{ups}$ $represents\ the\ numebr\ of\ ups\ in\ the\ path$

$\boldsymbol{S_{avg}}$ $represents\ the\ average\ stock\ price\ over\ the\ path$

$$For\ a\ particular\ path, \boldsymbol{S_{avg}} = \frac{\sum_{i=0}^{i=M} S(\frac{T*i}{M})}{M+1}$$

$\boldsymbol{f}$ $represents\ the\ payoff$:

$for\ Asian\ Call, f(S_{avg}) = \max(S_{avg} - K, 0)\ and\ for\ Asian\ Put, f(S_{avg}) = \max(K - S_{avg}, 0)$

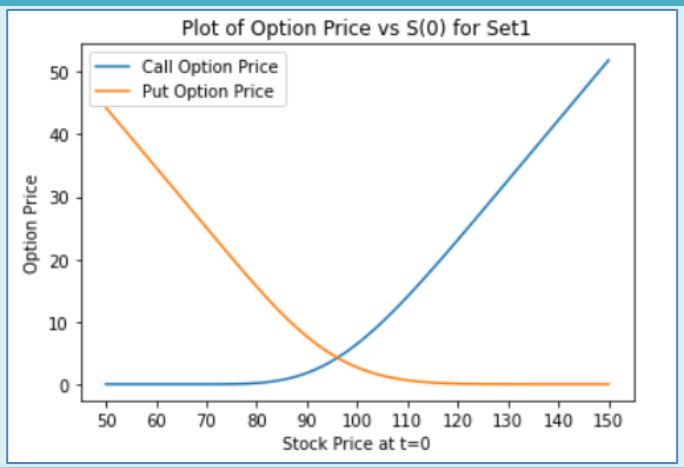
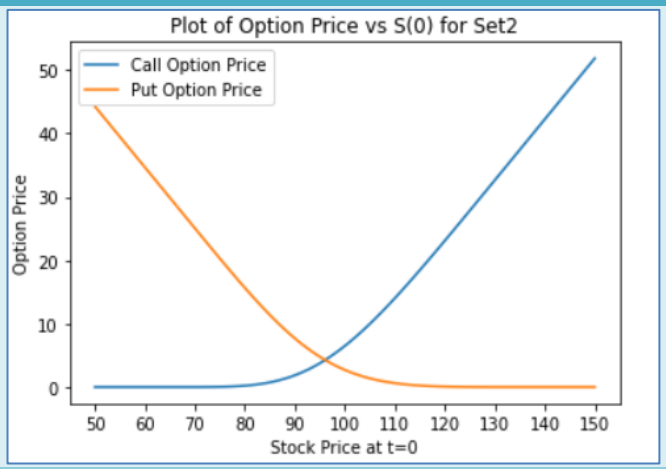
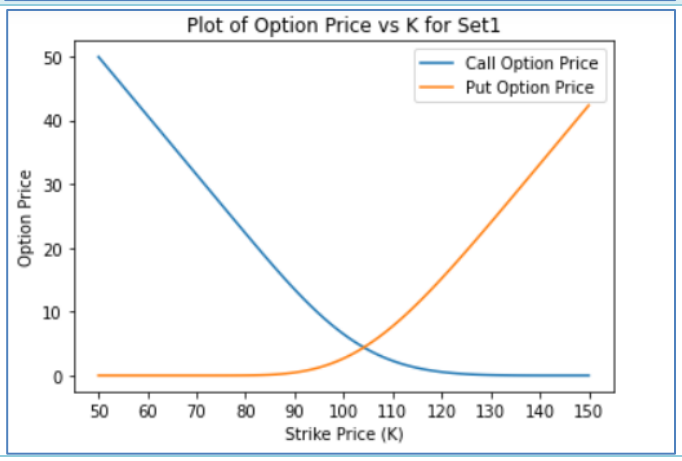
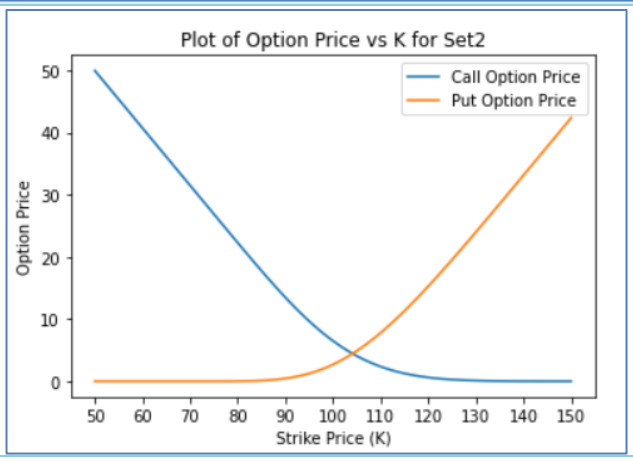
Each possible path was explored (which was required to compute the average), and hence the time complexity

for finding the required option price was exponential (2^M). Hence, the value of M was reduced from **100 to 10** to accommodate the high time complexities.

S(0) = 100 ; K= 100 ; T= 1 ; M= 10 ; r= 8% ; σ= 20%.
Using the above parameters, the option prices calculated are as follows:

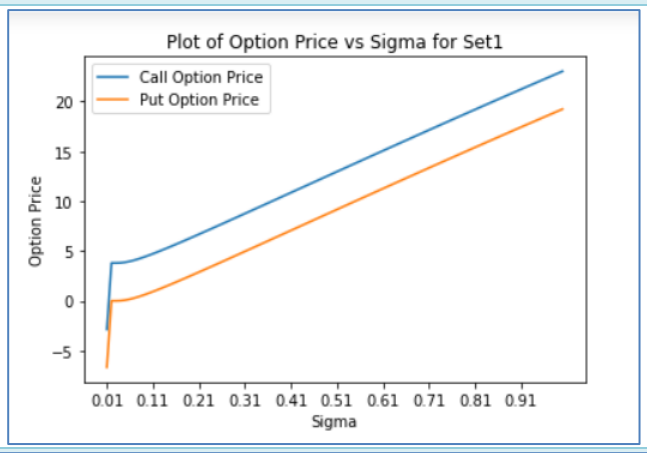
```
For Set-1
Asian Call Option Price = 6.47600305
Asian Put Option Price = 2.67794559
For Set-2
Asian Call Option Price = 6.49002938
Asian Put Option Price = 2.69197192
```

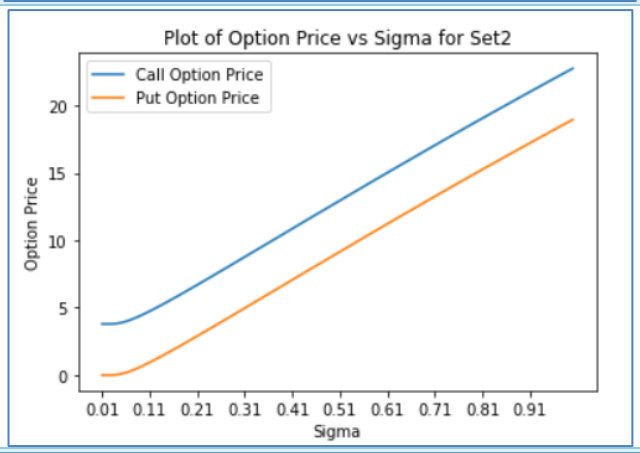
Similar to Q1,
The graph of the initial option prices was observed by varying a single parameter (2-D Plots) and two parameters (3-D Plots). All possible combinations have been explored. In most of the cases, Put and Call option prices have been plotted in the same graph for better comparisons.

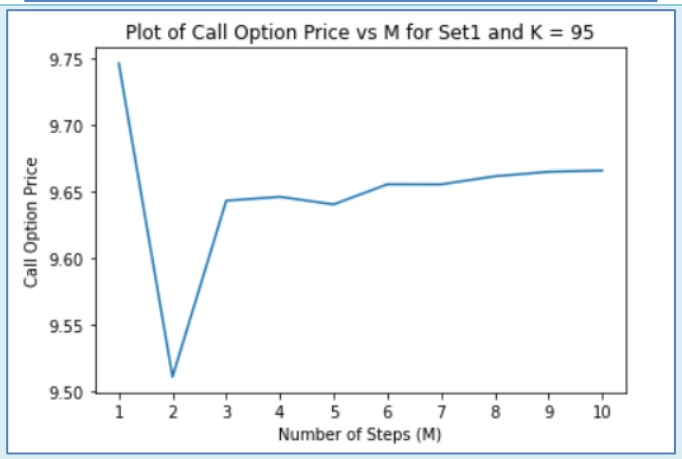
Set 1	Set 2
	
	

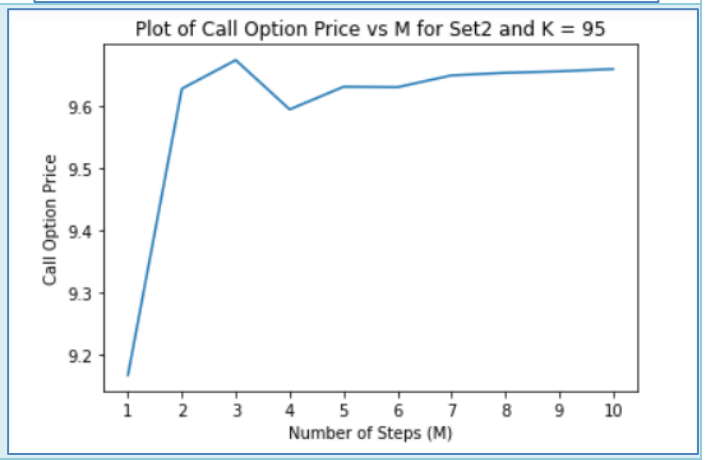

Plot of Option Price vs Interest Rate (r) for Set1
Call Option Price
Put Option Price
Option Price
Interest Rate (r)

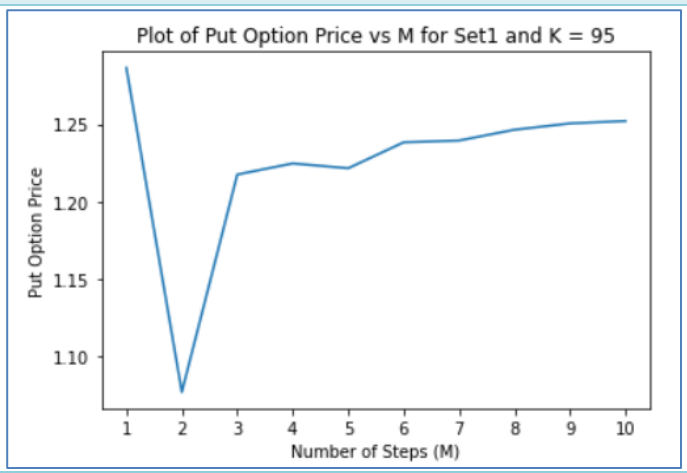

Plot of Option Price vs Interest Rate (r) for Set2
Call Option Price
Put Option Price
Option Price
Interest Rate (r)

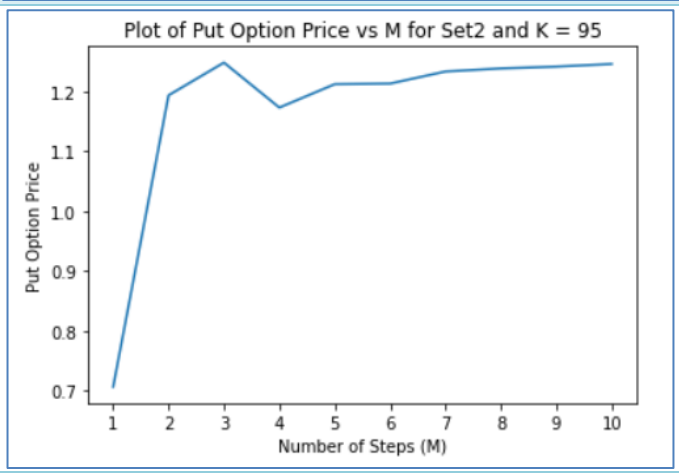

Plot of Option Price vs Sigma for Set1
Call Option Price
Put Option Price
Option Price
Sigma

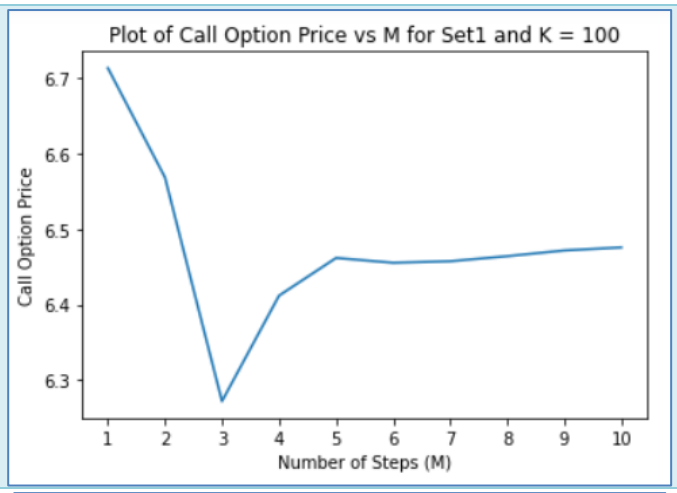

Plot of Option Price vs Sigma for Set2
Call Option Price
Put Option Price
Option Price
Sigma


Plot of Call Option Price vs M for Set1 and K = 95
Call Option Price
Number of Steps (M)


Plot of Call Option Price vs M for Set2 and K = 95
Call Option Price
Number of Steps (M)


Plot of Put Option Price vs M for Set1 and K = 95
Put Option Price
Number of Steps (M)


Plot of Put Option Price vs M for Set2 and K = 95
Put Option Price
Number of Steps (M)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Call Option Price
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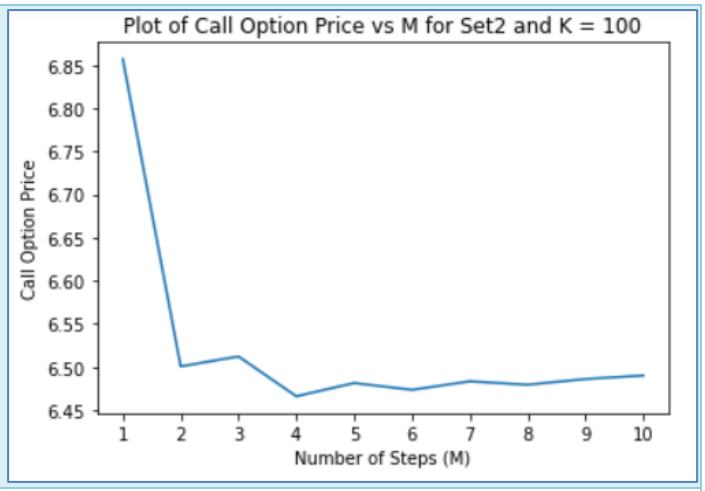
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Call Option Price
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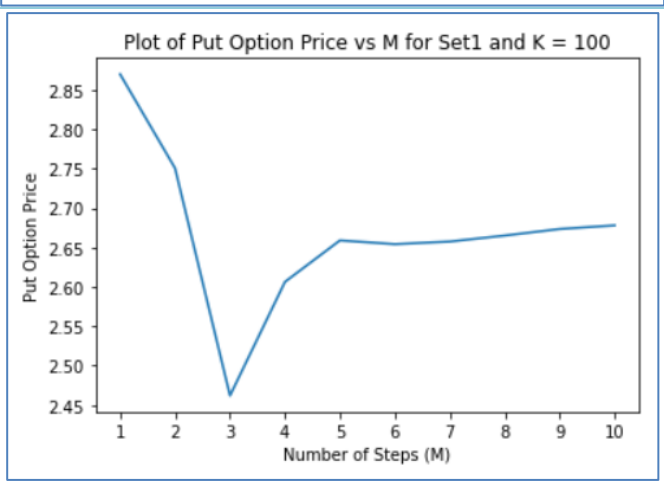
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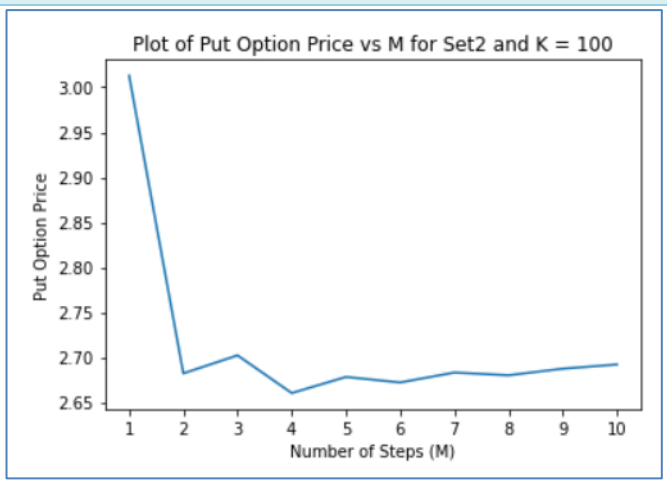
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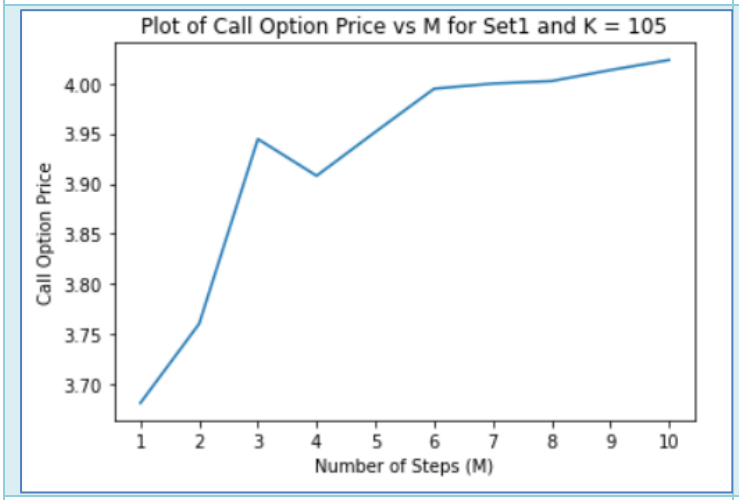
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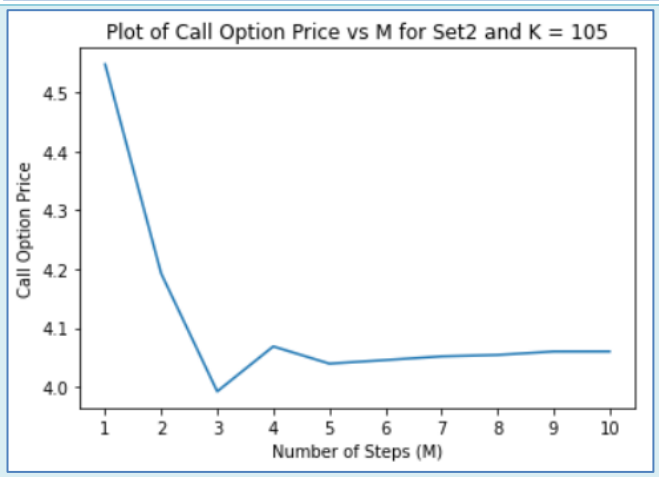
Call Option Price
Number of Steps (M)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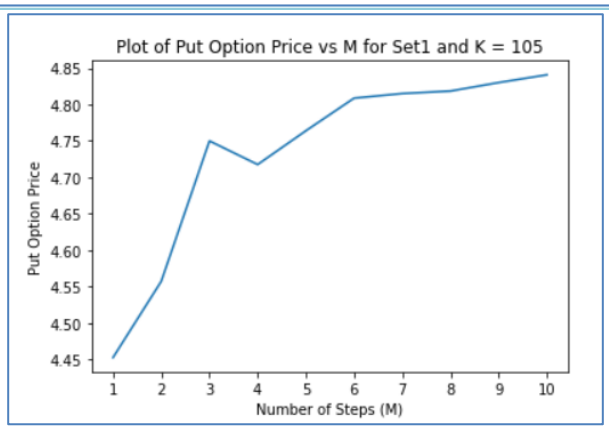
Call Option Price
Number of Steps (M)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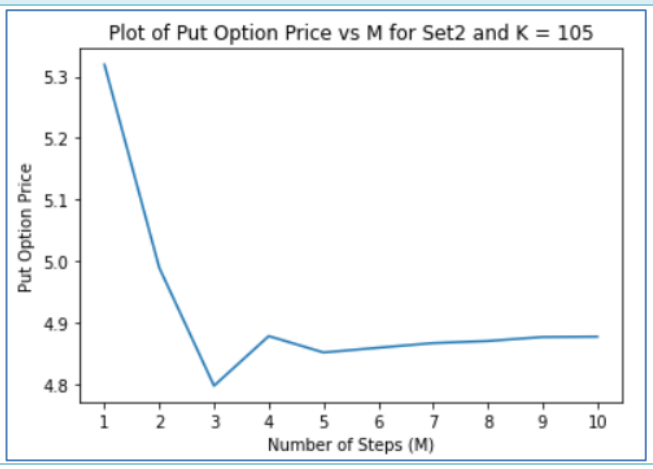
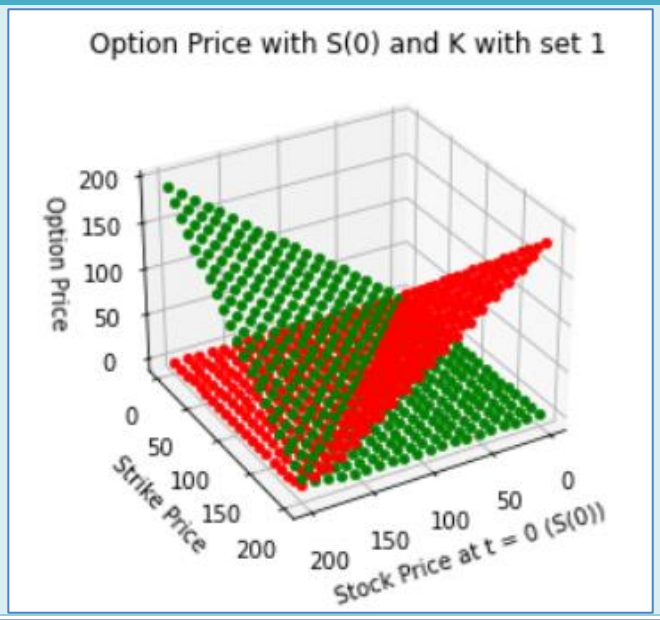
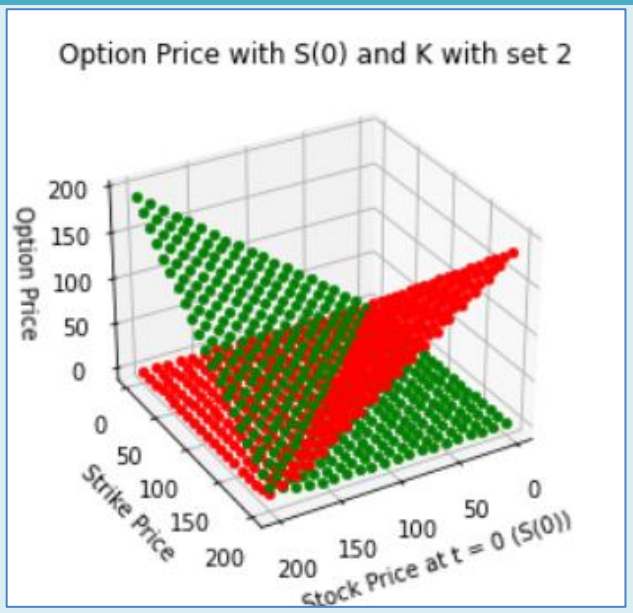
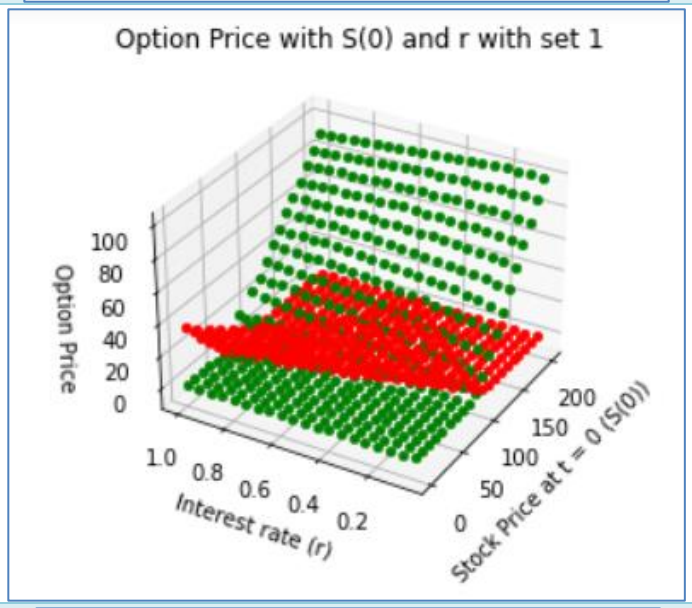
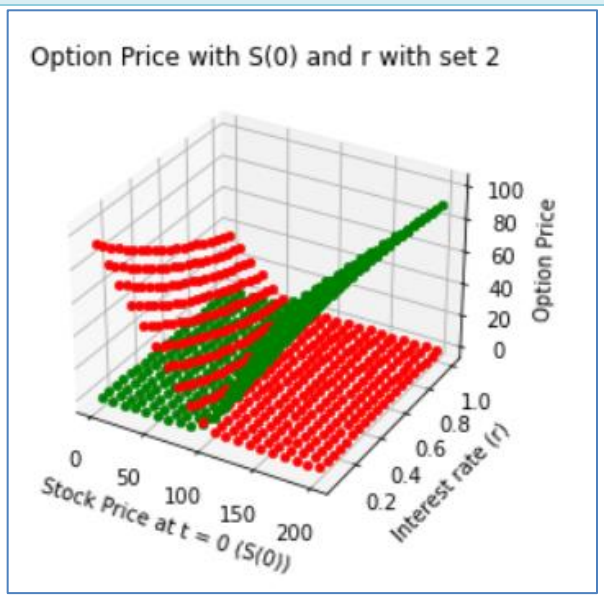
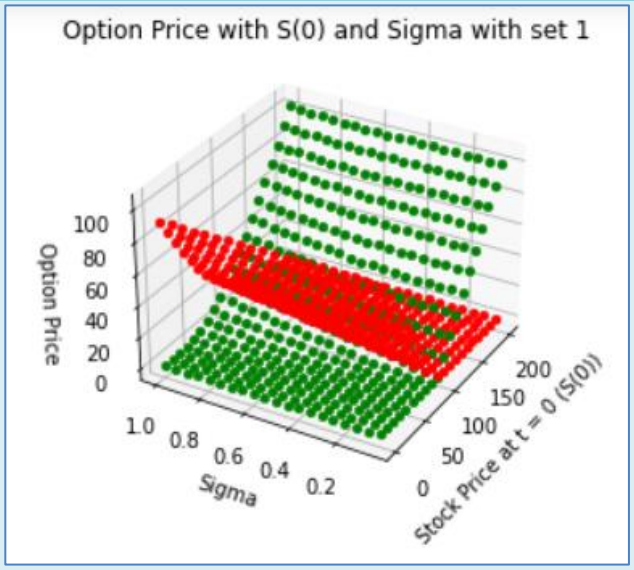
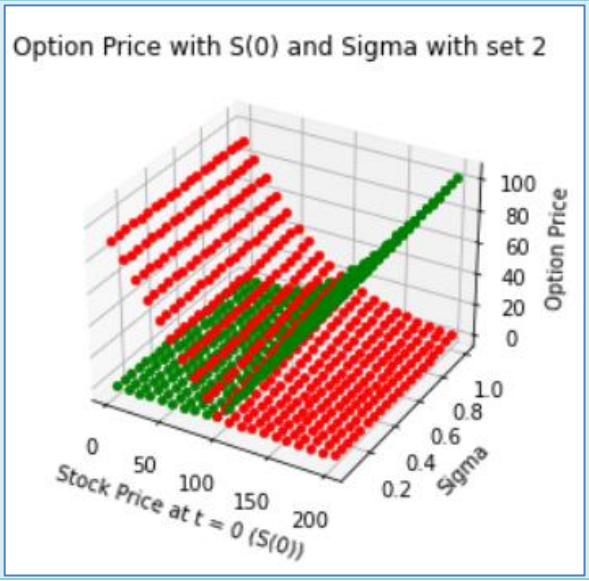
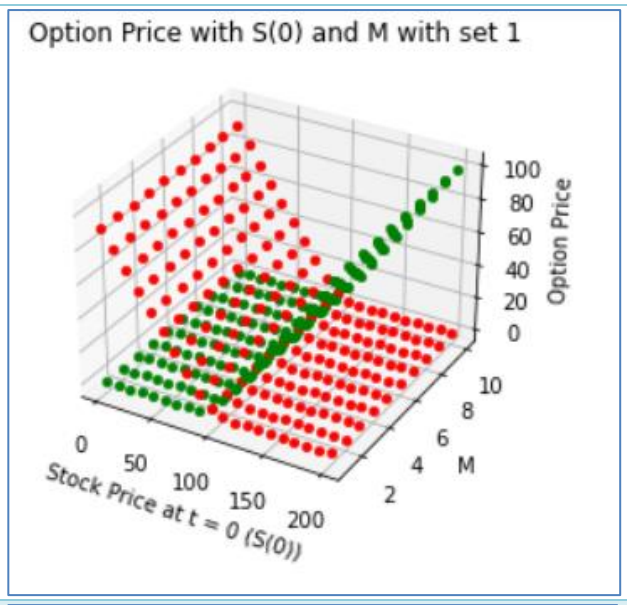
Put Option Price
Number of Steps (M)

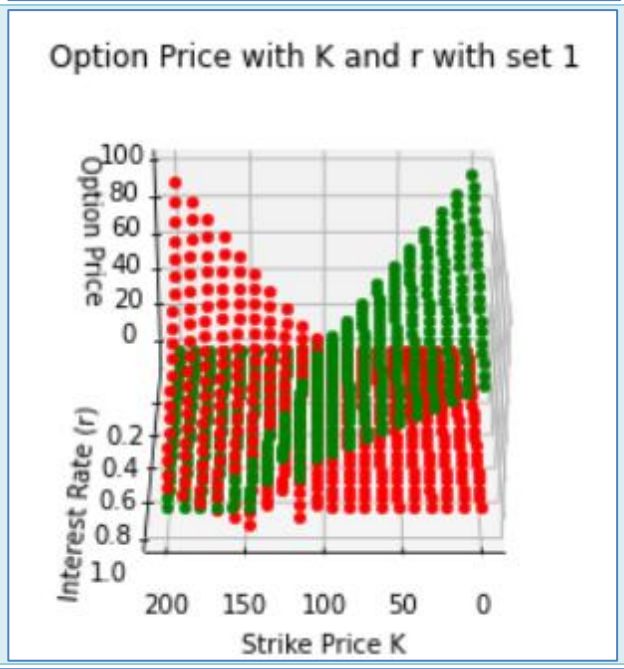

Plot of Put Option Price vs M for Set2 and K = 105
Put Option Price
Number of Steps (M)

Green represents Asian Call Option Price and Red Represents Asian Put Option Price

Set 1	Set 2
	
	
	


Option Price with S(0) and M with set 1
Option Price
Stock Price at t = 0 (S(0))
M


Option Price with S(0) and M with set 2
Option Price
Stock Price at t = 0 (S(0))
M


Option Price with K and r with set 1
Option Price
Interest Rate (r)
Strike Price K


Option Price with K and r with set 2
Option Price
Interest Rate (r)
Strike Price K


Option Price with K and Sigma with set 1
Option Price
Strike Price K
Sigma


Option Price with K and Sigma with set 2
Option Price
Strike Price K
Sigma


Option Price with K and M with set 1
Option Price
Strike Price K
M

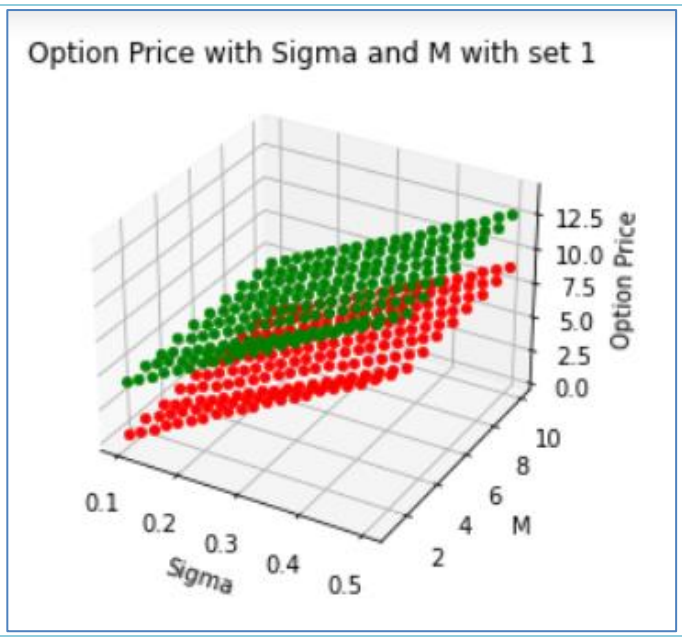

Option Price with K and M with set 2
Option Price
Strike Price K
M


Option Price with r and sigma with set 1
Option Price
Interest Rate (r)
Sigma


Option Price with r and sigma with set 2
Option Price
Interest Rate (r)
Sigma


Option Price with r and M with set 1
Option Price
Interest Rate (r)
M


Option Price with r and M with set 2
Option Price
Interest Rate (r)
M


Option Price with Sigma and M with set 1
12.5
10.0
7.5
5.0
2.5
0.0
Option Price
10
8
6
4
2
M
0.1
0.2
0.3
0.4
0.5
Sigma


Option Price with Sigma and M with set 2
12.5
10.0
7.5
5.0
2.5
0.0
Option Price
10
8
6
4
2
M
0.0
0.1
0.2
0.3
0.4
0.5
Sigma