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Fintech545 hw5
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Problem1

First, we calculate the time to maturity using calendar days. Import python 'datetime' package convert the date into datetime object and find the time to maturity. Next, apply the closed form bsm model given in class lecture.

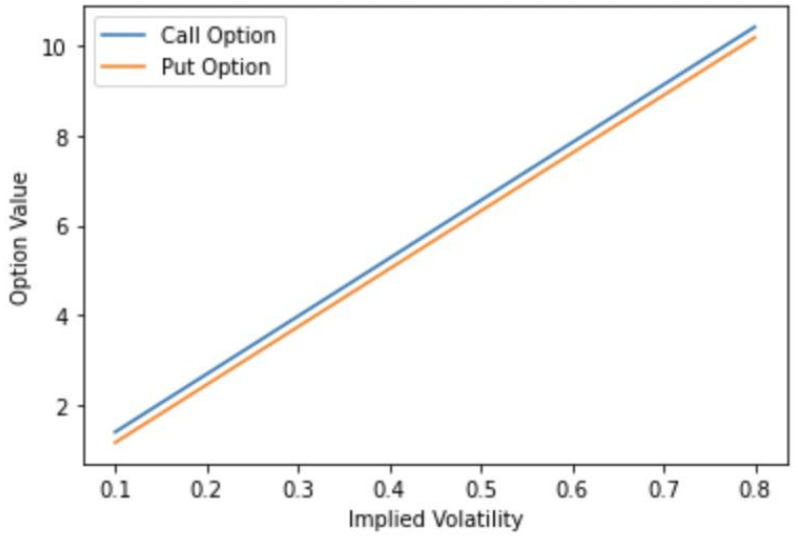
$$d_1 = \frac{ln\left(\frac{S}{X}\right)+\left(b+\frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

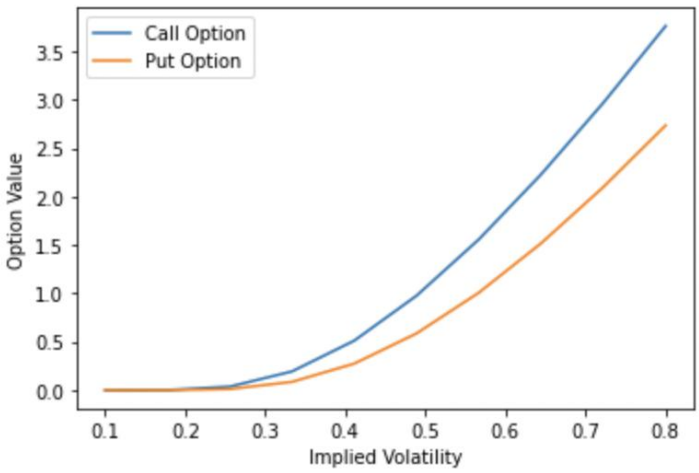
$$Call = Se^{(b-r)T}\Phi\left(d_1\right) - Xe^{-rT}\Phi\left(d_2\right)$$

$$Put = Xe^{-rT}\Phi\left(-d_2\right) - Se^{(b-r)T}\Phi\left(-d_1\right)$$

Next, calculate put call values for a range of implied volatility between 10% and 80%. We first plot the put call values with same underlying price and get the graph below:



Next, we set call underlying price with 20 addition and put underlying price with 20 minus, then plot the graph:



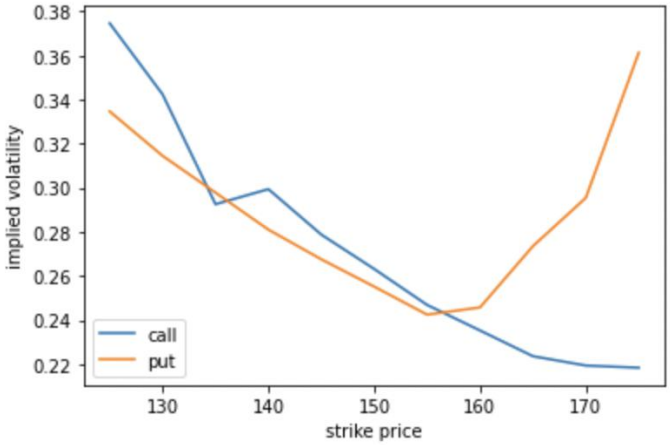
From graph we can see the option value increase with implied volatility, With demand increasing and supply decreasing, the option value will increase, given by the observation from the graph, we can see the demand increasing and supply decreasing, the implied volatility will also increase.

Problem2

First, we list all the variables for general bsm model and define a general bsm model function. To calculate the implied volatility, we use 'fsolve' method in python scipy.optimize package. The output is given below:

	Stock	Expiration	Type	Strike	Last Price	ivol
0	AAPL	4/21/2023	Call	125	27.300	0.374597
1	AAPL	4/21/2023	Call	130	22.575	0.342351
2	AAPL	4/21/2023	Call	135	17.750	0.292522
3	AAPL	4/21/2023	Call	140	13.850	0.299358
4	AAPL	4/21/2023	Call	145	9.975	0.278743
5	AAPL	4/21/2023	Call	150	6.700	0.263141
6	AAPL	4/21/2023	Call	155	4.050	0.246828
7	AAPL	4/21/2023	Call	160	2.210	0.235242
8	AAPL	4/21/2023	Call	165	1.035	0.223567
9	AAPL	4/21/2023	Call	170	0.460	0.219339
10	AAPL	4/21/2023	Call	175	0.195	0.218342
11	AAPL	4/21/2023	Put	125	0.405	0.334615
12	AAPL	4/21/2023	Put	130	0.665	0.314473
13	AAPL	4/21/2023	Put	135	1.120	0.297772
14	AAPL	4/21/2023	Put	140	1.840	0.280994
15	AAPL	4/21/2023	Put	145	3.010	0.267532
16	AAPL	4/21/2023	Put	150	4.750	0.255134
17	AAPL	4/21/2023	Put	155	7.150	0.242417
18	AAPL	4/21/2023	Put	160	10.575	0.245700
19	AAPL	4/21/2023	Put	165	14.925	0.273493
20	AAPL	4/21/2023	Put	170	19.425	0.295414
21	AAPL	4/21/2023	Put	175	24.625	0.361243

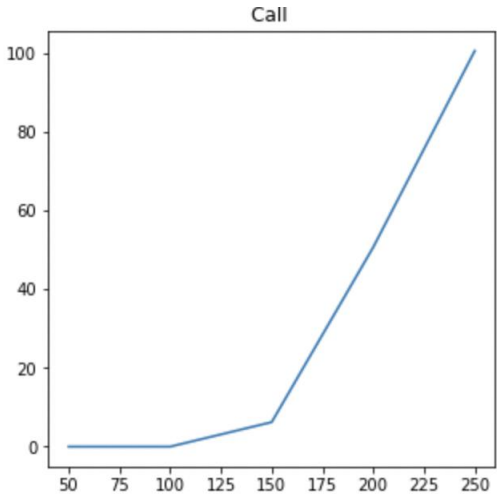
Next, draw the implied volatility with corresponded strike price:

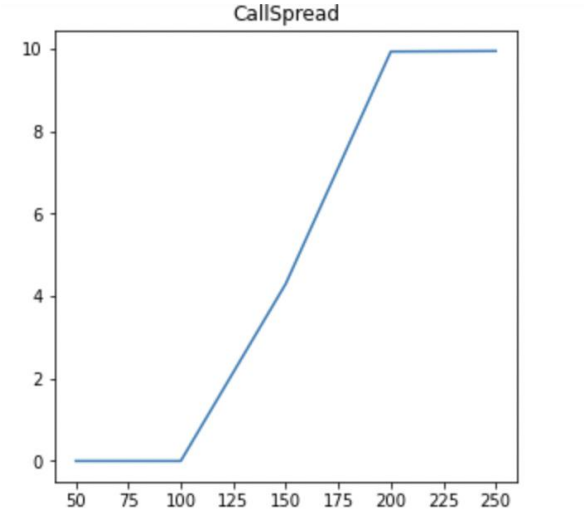


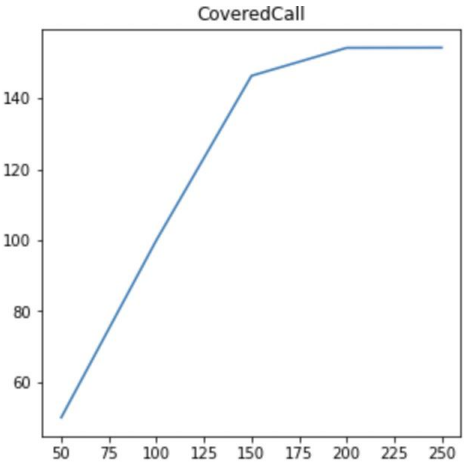
With strike price going higher, the implied volatility goes down first, then at some point, the strike prices differs substantially. These kind of options are either in-the-money or out-of-money. Such market dynamic will lead to the graph pattern.

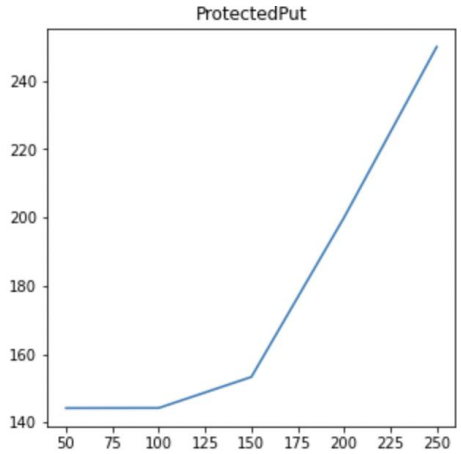
Problem3

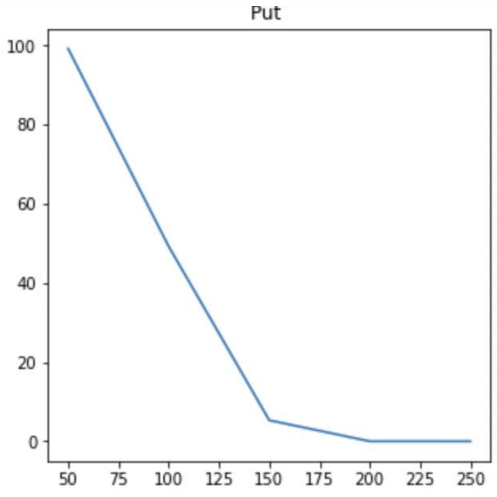
With a range of underlying values [50, 100, 150, 200, 250], we graph the portfolio value as below:

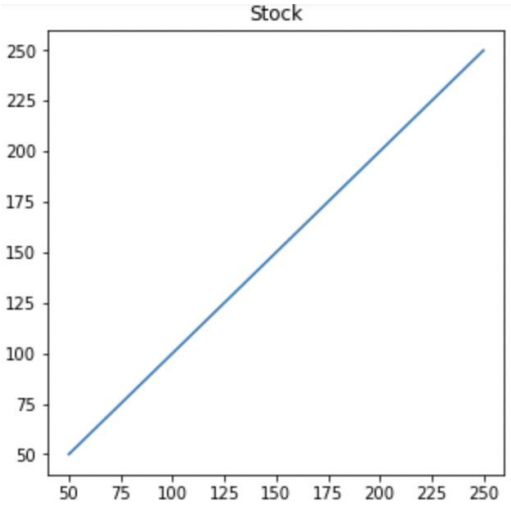


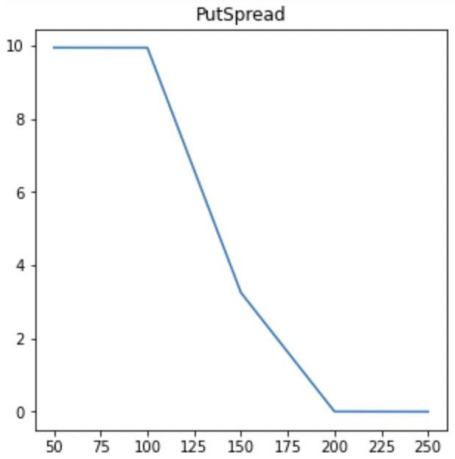

CallSpread
10
8
6
4
2
0
50 75 100 125 150 175 200 225 250

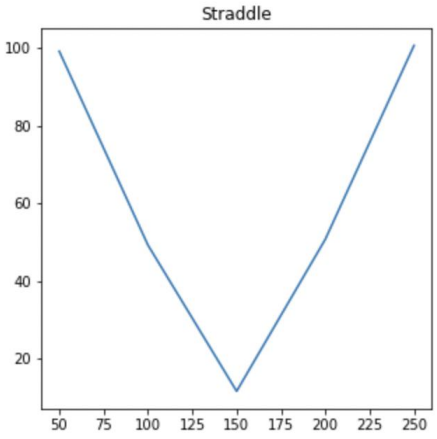

CoveredCall
140
120
100
80
60
50 75 100 125 150 175 200 225 250

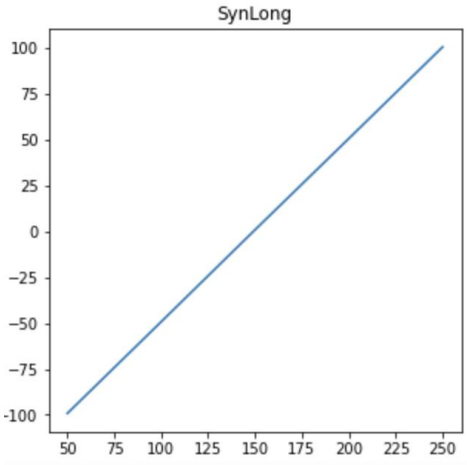

ProtectedPut
240
220
200
180
160
140
50 75 100 125 150 175 200 225 250


Put
100
80
60
40
20
0
50 75 100 125 150 175 200 225 250


Stock
250
225
200
175
150
125
100
75
50
50 75 100 125 150 175 200 225 250


PutSpread
10
8
6
4
2
0
50 75 100 125 150 175 200 225 250





For call and put: Basic options, risk are moderate
Callspread and putspread:Reduce the returns to lower the risk
Covercall and protectedput: they are mix of stock and option
Synlong and stock:Both has high risk but synlong has more return than stock
Straddle: has lowest risk

The mean, var and es of portfolio is given below;

	Mean	VaR	ES
Call	8.853603	1.480768	0.950756
CallSpread	4.806423	1.244200	0.822527
CoveredCall	145.338291	134.452168	131.003565
ProtectedPut	155.840830	146.634401	145.799971
Put	6.365668	0.907752	0.555817
PutSpread	3.345209	0.613972	0.382465
Stock	151.430180	135.066955	131.364529
Straddle	15.219271	12.591301	12.583657
SynLong	2.487936	-13.904047	-17.631984