Problem1

```
Call Greeks:
  Delta: 0.5342650692693474
  Gamma: 0.04005712070020568
  Vega: 19.71962666579851
  Theta: -24.898522316969515
  Rho: 7.583586080244792
  Carry Rho: 7.966245676523029

Put Greeks:
  Delta: -0.46573493073065264
  Gamma: 0.04005712070020568
  Vega: 19.71962666579851
  Theta: -18.786996965277233
  Rho: -7.277010958127815
  Carry Rho: -6.944415968299725
```

```
Delta:
  Call: 0.53400912
  Put: -0.46551181

Gamma:
  Call: 0.04003793
  Put: 0.04003796

Vega:
  Call: 19.71017887
  Put: 19.71017887

Theta:
  Call: -24.89852231
  Put: -18.78699697

Rho:
  Call: -0.38265960
  Put: -0.33259499

Carry Rho:
  Call: 7.96624576
  Put: -6.94441590
```

Comparing the values between the two methods for both a call and a put, we observe that the values obtained for Delta, Gamma, Vega, Theta, and Rho using the closed-form GBSM method are very close to the values calculated using the finite difference derivative method. This implies that both methods provide accurate results for estimating the Greeks, and their differences are minimal.

```
Binomial tree value without dividend for call: 4.2708470346370015
Binomial tree value without dividend for put: 3.684796414938882
```

```
Binomial tree value with dividend for call: 4.113922557559131
Binomial tree value with dividend for put: 4.108753125967308
```

```
delta
0.5362856902983992 -0.4905748584298486
```

```
gamma
0.03870802755298186 0.03787728330695117
```

```
vega
19.55157113225381 19.826294371316333
```

```
theta
-24.834258431046585 -18.54234922088782
```

```
rho
6.825927723814296 -7.2053590815586155
```

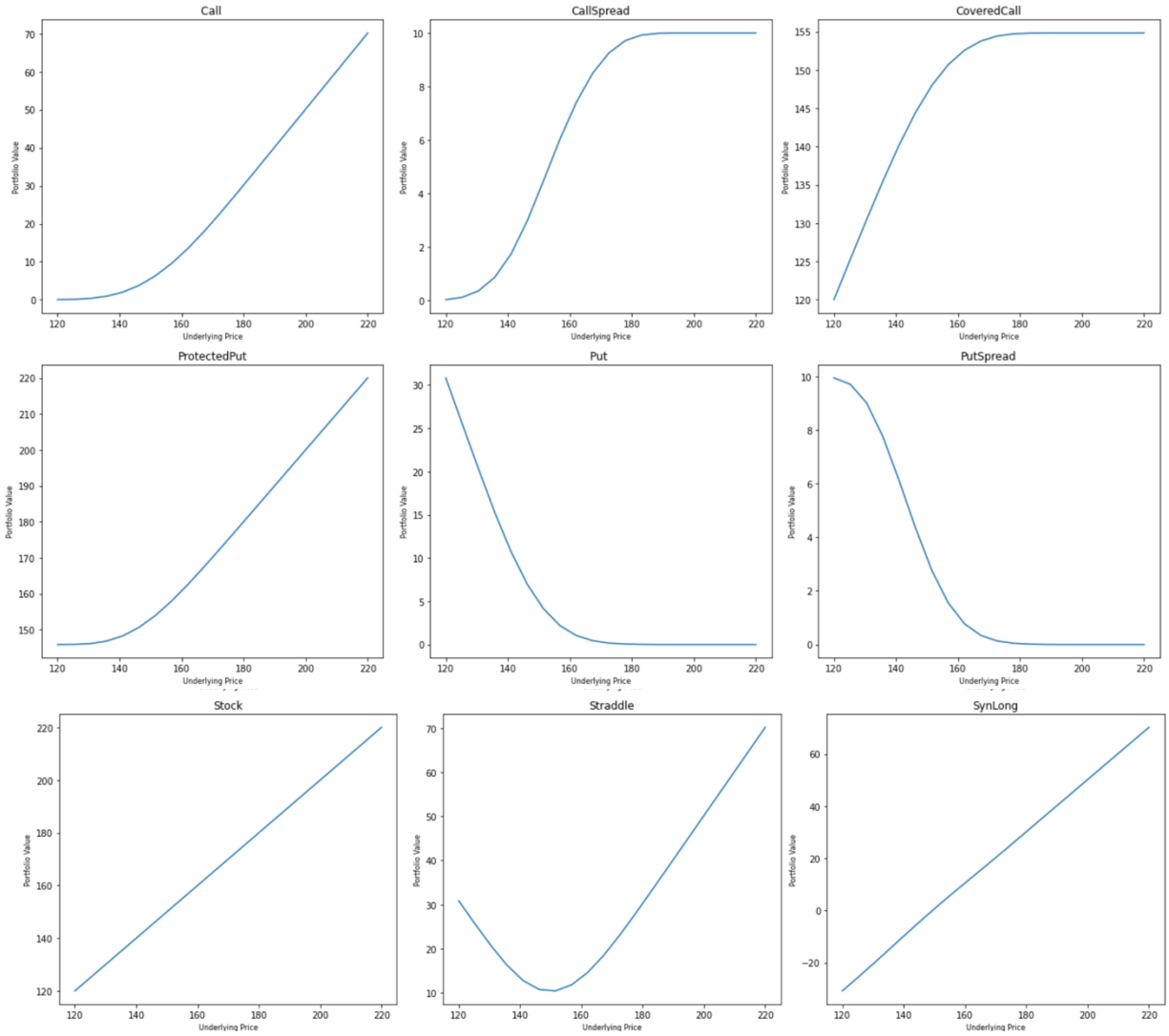
```
Sensitivity to dividend amount: Call: -0.109, Put: 0.510
```

The results show that the binomial tree values for American options are different when considering discrete dividends compared to when not considering them. The call value is

slightly lower when accounting for the dividend, whereas the put value is higher when accounting for the dividend.

The Greek values show the sensitivity of the options to various factors, such as the underlying price (Delta), the volatility (Vega), and the time to expiration (Theta). The positive Delta for the call and the negative Delta for the put indicate that the call option increases in value as the stock price increases, while the put option decreases in value as the stock price increases. The positive Gamma values for both options suggest that the options become more sensitive to price changes as the stock price moves. The Vega values for both options are positive, indicating that their values increase with an increase in implied volatility. The negative Theta values suggest that the options lose value as time passes. And for the sensitivity to dividend amount, This means that an increase in the dividend amount will result in a decrease in the value of the call option and an increase in the value of the put option.

Problem2



Compared with the graphs in last week, the first three graphs on the top are almost the same shape. The middle three graphs are completely different with the graphs in last week. And the left and right two graphs at the bottom line are almost the same with last week while the middle one are different.

	Mean	VaR($)	ES($)
Call	6.673385	6.193469	6.562662
CallSpread	4.064113	4.023378	4.362484
CoveredCall	145.246079	13.850938	18.803451
ProtectedPut	154.083535	7.643353	8.041389
Put	6.804384	4.352356	4.649988
PutSpread	3.828833	2.625317	2.854175
Stock	149.519227	17.739029	22.800091
Straddle	13.477769	1.346503	1.385781
SynLong	-0.130999	19.005682	24.336698

For the normal distribution of AAPL, the mean value are changed largely based on the result.

:

Portfolio	Mean	VaR	ES
Call	0	9.51986	11.938288
CallSpread	0	5.26384	6.601068
CoveredCall	0	10.901461	13.670872
ProtectedPut	0	12.141348	15.225741
Put	0	8.187534	10.267498
PutSpread	0	4.91698	6.166092
Stock	0	17.627131	22.105134
Straddle	0	1.332326	1.67079
SynLong	0	17.707393	22.205786

The delta normal distribution are much similar with the comparison.

Problem3

AAPL	0.172367
META	0.786795
UNH	-0.035623
MA	0.278287
MSFT	0.193225
NVDA	0.976604
HD	0.287746
PFE	0.007251
AMZN	0.331662
BRK-B	0.146686
PG	0.150760
XOM	0.118150
TSLA	0.132637
JPM	0.414015
V	0.267066
DIS	0.456722
GOOGL	0.265048
JNJ	-0.036789
BAC	0.378313
CSCO	0.276087

This is the expected annual return for each stock

	AAPL	META	UNH	MA	MSFT	NVDA	HD	PFE	AMZN	BRK-B	PG	XOM	TSLA	JPM	V	DIS	GOOGL	JNJ	BAC	CSCO
AAPL	0.188340	0.319052	0.044037	0.128232	0.153107	0.437065	0.104816	0.039941	0.206655	0.077369	0.051380	0.051059	0.229810	0.100360	0.111299	0.159982	0.177273	0.026469	0.111187	0.104630
META	0.319052	1.727888	0.033699	0.247333	0.327105	0.946391	0.233729	0.085805	0.518836	0.131225	0.069712	0.044441	0.385413	0.194800	0.202335	0.353429	0.453678	0.037640	0.229360	0.180327
UNH	0.044037	0.033699	0.059153	0.039753	0.043485	0.093597	0.033701	0.031836	0.048071	0.031962	0.031850	0.029528	0.045475	0.046407	0.037495	0.033432	0.037468	0.021687	0.046914	0.036107
MA	0.128232	0.247333	0.039753	0.166653	0.127537	0.376690	0.097115	0.044789	0.176738	0.072293	0.046667	0.046103	0.152587	0.109655	0.141003	0.153351	0.134188	0.021865	0.116965	0.087777
MSFT	0.153107	0.327105	0.043485	0.127537	0.196538	0.457646	0.114128	0.043865	0.232507	0.074605	0.047629	0.042828	0.192909	0.098814	0.107418	0.162438	0.195038	0.023958	0.111431	0.096642
NVDA	0.437065	0.946391	0.093597	0.376690	0.457646	1.968199	0.303998	0.097309	0.667123	0.202177	0.097498	0.129668	0.780242	0.291048	0.318938	0.503082	0.519115	0.043247	0.331852	0.262240
HD	0.104816	0.233729	0.033701	0.097115	0.114128	0.303998	0.174514	0.045171	0.178219	0.064463	0.052909	0.023209	0.120721	0.082029	0.084918	0.126262	0.118231	0.028763	0.085826	0.082952
PFE	0.039941	0.085805	0.031836	0.044789	0.043865	0.097309	0.045171	0.074790	0.053598	0.037036	0.032669	0.023058	0.027065	0.046553	0.040476	0.037852	0.038494	0.027442	0.044071	0.038794
AMZN	0.206655	0.518836	0.048071	0.176738	0.232507	0.667123	0.178219	0.053598	0.508076	0.105951	0.048796	0.058272	0.317128	0.140795	0.151333	0.264731	0.277326	0.030566	0.166623	0.129492
BRK-B	0.077369	0.131225	0.031962	0.072293	0.074605	0.202177	0.064463	0.037036	0.105951	0.068017	0.033468	0.044579	0.084542	0.078320	0.063237	0.089334	0.084684	0.021609	0.082650	0.061182
PG	0.051380	0.069712	0.031850	0.046667	0.047629	0.097498	0.052909	0.032669	0.048796	0.033468	0.067722	0.005803	0.031976	0.049021	0.043809	0.047742	0.041680	0.026665	0.046208	0.053439
XOM	0.051059	0.044441	0.029528	0.046103	0.042828	0.129668	0.023209	0.023058	0.058272	0.044579	0.005803	0.163921	0.058639	0.047056	0.035578	0.061258	0.045271	0.006990	0.051719	0.033563
TSLA	0.229810	0.385413	0.045475	0.152587	0.192909	0.780242	0.120721	0.027065	0.317128	0.084542	0.031976	0.058639	0.790052	0.113547	0.140388	0.234704	0.223062	0.014388	0.138084	0.101861
JPM	0.100360	0.194800	0.046407	0.109655	0.098814	0.291048	0.082029	0.046553	0.140795	0.078320	0.049021	0.047056	0.113547	0.173182	0.098639	0.132647	0.110007	0.026044	0.168416	0.088088
V	0.111299	0.202335	0.037495	0.141003	0.107418	0.318938	0.084918	0.040476	0.151333	0.063237	0.043809	0.035578	0.140388	0.098639	0.140497	0.132499	0.112411	0.020885	0.107133	0.076002
DIS	0.159982	0.353429	0.033432	0.153351	0.162438	0.503082	0.126262	0.037852	0.264731	0.089334	0.047742	0.061258	0.234704	0.132647	0.132499	0.329213	0.187803	0.022038	0.153822	0.103253
GOOGL	0.177273	0.453678	0.037468	0.134188	0.195038	0.519115	0.118231	0.038494	0.277326	0.084684	0.041680	0.045271	0.223062	0.110007	0.112411	0.187803	0.285440	0.024654	0.127421	0.110144
JNJ	0.026469	0.037640	0.021687	0.021865	0.023958	0.043247	0.028763	0.027442	0.030566	0.021609	0.026665	0.006990	0.014388	0.026044	0.020885	0.022038	0.024654	0.029895	0.024064	0.027942
BAC	0.111187	0.229360	0.046914	0.116965	0.111431	0.331852	0.085826	0.044071	0.166623	0.082650	0.046208	0.051719	0.138084	0.168416	0.107133	0.153822	0.127421	0.024064	0.202019	0.089019
CSCO	0.104630	0.180327	0.036107	0.087777	0.096642	0.262240	0.082952	0.038794	0.129492	0.061182	0.053439	0.033563	0.101861	0.088088	0.076002	0.103253	0.110144	0.027942	0.089019	0.157866

This is the covariance of each stock

The most efficient portfolio consists of:

	weights(%)
AAPL	0.00
META	4.16
UNH	0.00
MA	0.00
MSFT	0.00
NVDA	1.08
HD	7.84
PFE	0.00
AMZN	0.00
BRK-B	0.00
PG	9.06
XOM	0.00
TSLA	0.00
JPM	58.13
V	0.00
DIS	12.92
GOOGL	0.00
JNJ	0.00
BAC	0.00
CSCO	6.81

The Portfolio's Sharpe Ratio is: 1.0561289553450046