Problem 1

- ● Current Stock Price $151.03
- ● Strike Price $165
- ● Current Date 03/13/2022
- ● Options Expiration Date 04/15/2022
- ● Risk Free Rate of 4.25%
- ● Continuously Compounding Coupon of 0.53%

Implement the closed form greeks for GBSM. Implement a finite difference derivative calculation. Compare the values between the two methods for both a call and a put.

Implement the binomial tree valuation for American options with and without discrete dividends. Assume the stock above:

● Pays dividend on 4/11/2022 of $0.88
Calculate the value of the call and the put. Calculate the Greeks of each. What is the sensitivity of the put and call to a change in the dividend amount?

The result is shown as following:

Price of call option with no dividend: 4.27 Price of call option with dividend: 4.12

Price of put option with no dividend: 3.68 Price of put option with dividend: 4.11

The value of call options decrease with dividend while the put value increase in this situation.

The change rate of call is (4.12 – 4.27) / 4.27 = -0.035

The change rate of put is (4.11 – 3.68) / 3.68 = 0.117 the put option is more sensitive.

	gbsm_closed_call	gbsm_closed_put	gbsm_derivative_call	gbsm_derivative_put	bt_american_call	bt_american_put
Delta	0.706362	-0.292927	0.756421	-0.237890	7.033031e-01	-0.300620
Gamma	0.024801	0.024801	0.039565	0.039565	3.115041e-09	0.000000
Vega	19.023726	19.023726	9.607762	9.607762	1.923876e+01	19.330693
Theta	-21.315890	-15.988340	-13.548843	-32.940425	-2.185380e+01	-16.151113
Rho	13.055622	-6.299386	4.586537	-1.574575	1.233504e+01	-5.949192
Carry Rho	14.321671	-5.939169	9.441832	-3.101537	NaN	NaN

Problem 2

Using the options portfolios from Problem3 last week (named problem2.csv in this week's repo) and assuming :

- ● American Options

- ● Current Date 03/03/2023
- ● Current AAPL price is 165
- ● Risk Free Rate of 4.25%
- ● Dividend Payment of $1.00 on 3/15/2023

Using DailyPrices.csv. Fit a Normal distribution to AAPL returns – assume 0 mean return. Simulate AAPL returns 10 days ahead and apply those returns to the current AAPL price (above). Calculate Mean, VaR and ES.

	Mean	VaR	ES
Straddle	1.734536	1.235151	1.255981
SynLong	-0.799951	18.566214	22.550447
CallSpread	-0.206661	3.934776	4.221094
PutSpread	0.553890	2.683594	2.870239
Stock	-0.260490	17.318129	21.044675
Call	0.467292	6.099346	6.411479
Put	1.267244	4.436432	4.675090
CoveredCall	-0.902307	13.465899	17.089842
ProtectedPut	0.741073	7.578518	7.880233

Calculate VaR and ES using Delta-Normal.

	Mean	VaR	ES
Straddle	1.761717	1.225568	1.249341
SynLong	-0.533543	1.174581	1.415279
CallSpread	-0.131500	0.936325	2.090806
PutSpread	0.488775	0.067056	0.088895
Stock	0.000000	-0.000000	-0.000000
Call	0.614087	0.754647	0.766513
Put	1.147630	0.469972	0.483347
CoveredCall	-0.739787	4.610202	7.438171
ProtectedPut	0.923255	0.478314	0.479471

Present all VaR and ES values a $ loss, not percentages. Compare these results to last week's results.

	Mean	VaR	ES
Straddle	1.326614	1.380597	1.387930
SynLong	-0.424802	16.414656	20.073559
CallSpread	-0.187994	3.910205	4.199130
PutSpread	0.359855	2.553987	2.748505
Stock	-0.223259	16.170964	19.807763
Call	0.450906	6.060526	6.382465
Put	0.875708	4.265698	4.520131
CoveredCall	-0.844624	12.346409	15.870225
ProtectedPut	0.495880	8.112426	8.718021

From the result we can see that as the delta normal compare with last week's result, the result is quite similar as using the normal distribution. But after using the delta normal, the VaR and ES reduce a lot. The smallest change is the straddle as it is an options trading strategy that involves buying both a call option and a put option on the same underlying asset .

Problem 3

Use the Fama French 3 factor return time series (F-F_Research_Data_Factors_daily.CSV) as well as the Carhart Momentum time series (F-F_Momentum_Factor_daily.CSV) to fit a 4 factor model to the following stocks.

AAPL	FB	UNH	MA
MSFT	NVDA	HD	PFE
AMZN	BRK-B	PG	XOM
TSLA	JPM	V	DIS
GOOGL	JNJ	BAC	CSCO

Fama stores values as percentages, you will need to divide by 100 (or multiply the stock returns by 100) to get like units.

Based on the past 10 years of factor returns, find the expected **annual** return of each stock. Construct an annual covariance matrix for the 10 stocks.
Assume the risk free rate is 0.0425. Find the super efficient portfolio.

the expected **annual** return of each stock is shown as following:

Date	AAPL	META	UNH	MA	MSFT	NVDA	HD	PFE	AMZN	BRK-B	PG	XOM	TSLA	JPM	V	DIS	GOOGL	JNJ	BAC	CSCO
-01-31	0.157144	0.017941	0.2538	0.222901	0.155944	0.279721	0.120591	0.076962	-0.042945	0.129923	0.08154	0.521821	-0.033253	0.098273	0.241054	-0.155372	-0.017075	0.124206	-0.112301	0.147807

the super efficient portfolio is:

	AAPL	META	UNH	MA	MSFT	NVDA	HD	PFE	AMZN	BRK-B	PG	XOM	TSLA	JPM	V	DIS	GOOGL	JNJ	BAC	CSCO
weight %	0.0	0.0	22.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.44	0.0	0.0	12.93	0.0	0.0	7.05	0.0	0.0

And The Portfolio's Sharpe Ratio is: 1.65