Problem 1

```
Greeks for call:
Delta:0.5340091224850149
gamma:0.040037930803986446
Vega: 19.710179716477544
theta: -24.898522316969515
rho: 7.583586080244792
carry_rho: 7.966245676523029

Greeks for Put:
Delta:-0.4655118142202754
gamma:0.040037930803986446
Vega: 19.710179716477544
theta: -18.786996965277233
rho: -7.277010958127815
carry_rho: -6.944415968299725
```

```
Finite Difference for call:
Delta:0.5380088534424488
gamma:0.04003661620579635
Vega: 19.71119469377811
theta: -24.322438934413526
rho: 7.583586080244792
carry_rho: 7.999955781329504

Finite Difference for Put:
Delta:-0.4615120832627184
gamma:0.04003661620615162
Vega: 19.71119469377811
theta: -18.212374651071173
rho: -7.277010958127815
carry_rho: -6.915425164275948
```

Here are the values for the two methods for call and put. As we can see, the results are almost the same.

After implement the binomial tree valuation for American options with and without discrete dividends, the value for call and put and the Greeks are as follows:

```
Call option without dividend: 4.2698585632362684
Put option without dividend: 3.684138176821656
Call option with dividend: 4.112836095267345
Put option with dividend: 4.1105345298444895
```

```
Greeks for call:
Deta:0.07142098722151269
gamma:-1.8041124150158794e-14
Vega: 6.715925765729786
theta: -8.008532885682785
rho: 1.1144661756958774

Greeks for Put:
Deta:-0.9581440573525501
gamma:0.00879965784146286
Vega: 4.092784252978632
theta: -2.762962752360565
rho: -2.5389971559906854
```

```
Greeks for call:
Deta:0.07142098722151269
gamma:-1.8041124150158794e-14
Vega: 6.715925765729786
theta: -8.008532885682785
rho: 1.1144661756958774
delta dividend : 0.0

Greeks for Put:
Deta:-0.9999999999999165
gamma:3.1086244689504383e-13
Vega: 0.0
theta: 3.5178104709400415
rho: -7.482600641783854
delta dividend : 0.9980806115089891
```

An increase in the dividend amount would increase the dividend yield, which would decrease the value of a call option and increase the value of a put option. A decrease in the dividend amount would decrease the dividend yield, which would increase the value of a call option and decrease the value of a put option.

Problem 2

Portfolio	Mean	VaR	ES
Call	0.364191	2.412045	2.973048
CallSpread	-0.468312	3.165946	4.021637
CoveredCall	-1.496461	11.147061	13.957524
ProtectedPut	1.334180	3.957125	4.877468
Put	0.948173	2.376212	2.923318
PutSpread	0.373035	1.246215	1.550986
Stock	0.548978	5.585891	6.885389
Straddle	1.312364	4.757654	6.126322
SynLong	-0.583983	0.003567	0.004534

These are the results obtained by simulating the returns using a normal distribution.

Compared to last week's results, for Call, VaR and ES are both smaller, but mean is also smaller. For ProtectedPut, the mean is similar, but VaR and ES are much smaller. For Put, it has a higher mean and at the same time have lower VaR and ES. For SynLong, it has the most significantly reduce of VaR and ES. For Stock, VaR and ES are also much lower, but mean stays almost the same. Overall, the mean didn't change significantly, but the risk has reduced a lot.

Problem 3

The expected annual return of each stock are as follows:

Date	AAPL	META	UNH	MA	MSFT	NVDA	HD	PFE	AMZN	BRK-B	PG	XOM	TSLA	JPM
2023-01-31	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

V	DIS	GOOGL	JNJ	BAC	CSCO
0.241054	-0.155372	-0.017075	0.124206	-0.112301	0.147807

The weights of the super efficient portfolio are as follows:

	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

The portfolio's sharp ratio is 1.65