PROBLEM 1

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BSM vs Finite Difference Greeks Comparison:
Call Option Greeks (BSM): {'delta': 0.08301107089626869, 'gamma': 0.016830979206204362, 'vega': 6.938710929513443, 'theta': -8.196615884194502, 'rho': 1.1025939156368187}
Call Option Greeks (Finite Difference): {'delta': 0.08297130338341674, 'gamma': 0.016824763804379472, 'vega': 6.938710350752331, 'theta': -8.126520224163158, 'rho': 1.102593926054496}
Put Option Greeks (BSM): {'delta': -0.9169889291037313, 'gamma': 0.016830979206204362, 'vega': 6.938710929513443, 'theta': -1.2110094733534407, 'rho': -13.758003122735788}
Put Option Greeks (Finite Difference): {'delta': -0.9165496332741441, 'gamma': 0.016834178495628294, 'vega': 6.938710350681276, 'theta': -1.9409893427280167, 'rho': -13.758003112513961

Option Prices Comparison (BSM vs Binomial):
Call Price (BSM): 0.3358
Put Price (BSM): 13.7454
Call Price (Binomial, without dividend): 0.3418
Put Price (Binomial, without dividend): 165.0000
Call Price (Binomial, with dividend): 0.3418
Put Price (Binomial, with dividend): 165.3200
Call Option Greeks (Binomial Tree): {'delta': 0.07963234403440822, 'gamma': -1.4432899320127035e-07, 'vega': 6.71240557054309, 'theta': -7.947810146471112, 'rho': 1.113612033041278}
Put Option Greeks (Binomial Tree): {'delta': 0.0, 'gamma': 0.0, 'vega': 0.0, 'theta': 0.0, 'rho': 0.0}
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Problem2

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price=4.850037908620827
iv(call): 0.0011
iv(put): 0.46727137374877914
delta of call: 1.0
delta of put: -0.24963939311205408
VaR&ES of call at 95.0% confidence level: (-0.9593093389896467, -0.9552310159117419)
VaR&ES of put at 95.0% confidence level: (-1.7260930138812762, 0.006346647213195888)
Total VaR of straddle at 95.0% confidence level: -2.685402352870923
Total ES of straddle at 95.0% confidence level: -0.948884368698546
VaR&ES of call at 95.0% confidence level: (-0.9593093389896467, -0.9552310159117419)
VaR&ES of put at 95.0% confidence level: (1.7260930138812762, -0.006346647213195888)
Total VaR of straddle at 95.0% confidence level: 0.7667836748916296
Total ES of straddle at 95.0% confidence level: -0.9615776631249378
VaR&ES of call1 at 95.0% confidence level: (-0.9593093389896467, -0.9552310159117419)
VaR&ES of call2 at 95.0% confidence level: (0.9591448536269515, 0.9554372871924925)
Total VaR of callspread at 95.0% confidence level: -0.0001644853626951992
Total ES of callspread at 95.0% confidence level: 0.00020627128075068057

VaR&ES of put1 at 95.0% confidence level: (-1.7260930138812762, 0.006346647213195888)
VaR&ES of put2 at 95.0% confidence level: (1.665914388945846, 0.0691197762779685)
Total VaR of putspread at 95.0% confidence level: -0.060178624935430136
Total ES of putspread at 95.0% confidence level: 0.07546642349116439
VaR&ES of call at 95.0% confidence level: (-0.9593093389896467, -0.9552310159117419)
VaR&ES of put at 95.0% confidence level: (-1.7260930138812762, 0.006346647213195888)
Total VaR of callput at 95.0% confidence level: -2.685402352870923
Total ES of callput at 95.0% confidence level: -0.948884368698546
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problem 3

Expected Annual Returns for Each Stock:
AAPL: 17.25%
META: 41.72%
UNH: 22.38%
MA: 9.31%
MSFT: 11.66%
NVDA: 71.94%
HD: 7.67%
PFE: -10.19%
AMZN: 14.15%
BRK-B: 17.33%
PG: 15.79%
XOM: -2.30%
TSLA: -1.96%
JPM: 27.96%
V: 5.14%
DIS: 5.96%
GOOGL: 11.19%
JNJ: 4.42%
BAC: 18.94%
CSCO: -13.09%

Annual Covariance Matrix for the 20 stocks:

	AAPL	META	UNH	MA	MSFT	NVDA	HD
AAPL	0.050501	0.020870	-0.001577	0.010380	0.021561	0.033939	0.010867
META	0.020870	0.136272	-0.011660	0.015539	0.041722	0.077580	0.010079
UNH	-0.001577	-0.011660	0.049432	0.005066	-0.001927	-0.016474	0.006551
MA	0.010380	0.015539	0.005066	0.027007	0.012275	0.021657	0.011621
MSFT	0.021561	0.041722	-0.001927	0.012275	0.039604	0.045418	0.011498
NVDA	0.033939	0.077580	-0.016474	0.021657	0.045418	0.253770	0.023843
HD	0.010867	0.010079	0.006551	0.011621	0.011498	0.023843	0.042762
PFE	0.002864	0.000547	0.010636	0.003087	0.005221	-0.016984	0.005594
AMZN	0.024202	0.064354	-0.006390	0.015380	0.035189	0.067779	0.016908
BRK-B	0.006499	0.008382	0.006006	0.010321	0.006653	0.003171	0.010077
PG	-0.000199	-0.000426	0.007212	0.004023	0.002121	-0.009521	0.003260
XOM	-0.002407	-0.005812	0.001574	0.004131	-0.005784	-0.017253	0.005945
TSLA	0.046972	0.033953	0.001457	0.021594	0.029237	0.071756	0.028368
JPM	0.001670	0.006064	0.004938	0.008724	0.004695	0.005717	0.013261
V	0.010306	0.014285	0.003748	0.019691	0.012743	0.018001	0.010632
DIS	0.003784	0.010023	0.000456	0.007901	0.008303	0.015492	0.012559
GOOGL	0.025260	0.043208	-0.004703	0.011537	0.029757	0.051591	0.007758
JNJ	0.000410	-0.005947	0.008443	0.004104	-0.000898	-0.020411	0.006870
BAC	0.005001	0.005183	0.005151	0.006302	0.004584	-0.000161	0.022778
CSCO	0.008293	0.007240	0.005028	0.009910	0.008667	0.010232	0.013129

	PFE	AMZN	BRK-B	PG	XOM	TSLA	JPM
AAPL	0.002864	0.024202	0.006499	-0.000199	-0.002407	0.046972	0.001670
META	0.000547	0.064354	0.008382	-0.000426	-0.005812	0.033953	0.006064
UNH	0.010636	-0.006390	0.006006	0.007212	0.001574	0.001457	0.004938
MA	0.003087	0.015380	0.010321	0.004023	0.004131	0.021594	0.008724
MSFT	0.005221	0.035189	0.006653	0.002121	-0.005784	0.029237	0.004695
NVDA	-0.016984	0.067779	0.003171	-0.009521	-0.017253	0.071756	0.005717
HD	0.005594	0.016908	0.010077	0.003260	0.005945	0.028368	0.013261
PFE	0.062464	0.002466	0.010833	0.002163	0.003940	0.002940	0.010246
AMZN	0.002466	0.081874	0.008978	-0.001785	-0.005728	0.046419	0.008206
BRK-B	0.010833	0.008978	0.016801	0.004501	0.008345	0.009049	0.013116
PG	0.002163	-0.001785	0.004501	0.022672	0.002867	-0.003999	0.000597
XOM	0.003940	-0.005728	0.008345	0.002867	0.041071	-0.001924	0.011345
TSLA	0.002940	0.046419	0.009049	-0.003999	-0.001924	0.293876	0.020562
JPM	0.010246	0.008206	0.013116	0.000597	0.011345	0.020562	0.033249
V	0.004419	0.013531	0.009401	0.004643	0.002715	0.021799	0.008395
DIS	0.008145	0.013054	0.008012	-0.000892	0.009776	0.026769	0.011302
GOOGL	0.003924	0.045175	0.008250	-0.000272	-0.004480	0.031925	0.006162
JNJ	0.016889	-0.002814	0.007518	0.005866	0.005893	-0.001402	0.007898
BAC	0.010263	0.008630	0.014265	0.002463	0.016620	0.028866	0.028629
CSCO	0.010953	0.018381	0.007840	0.002357	0.008121	0.017523	0.009708

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              V       DIS     GOOGL       JNJ       BAC      CSCO
AAPL   0.010306  0.003784  0.025260  0.000410  0.005001  0.008293
META   0.014285  0.010023  0.043208 -0.005947  0.005183  0.007240
UNH    0.003748  0.000456 -0.004703  0.008443  0.005151  0.005028
MA     0.019691  0.007901  0.011537  0.004104  0.006302  0.009910
MSFT   0.012743  0.008303  0.029757 -0.000898  0.004584  0.008667
NVDA   0.018001  0.015492  0.051591 -0.020411 -0.000161  0.010232
HD     0.010632  0.012559  0.007758  0.006870  0.022778  0.013129
PFE    0.004419  0.008145  0.003924  0.016889  0.010263  0.010953
AMZN   0.013531  0.013054  0.045175 -0.002814  0.008630  0.018381
BRK-B  0.009401  0.008012  0.008250  0.007518  0.014265  0.007840
PG     0.004643 -0.000892 -0.000272  0.005866  0.002463  0.002357
XOM    0.002715  0.009776 -0.004480  0.005893  0.016620  0.008121
TSLA   0.021799  0.026769  0.031925 -0.001402  0.028866  0.017523
JPM    0.008395  0.011302  0.006162  0.007898  0.028629  0.009708
V      0.022884  0.005352  0.011023  0.004906  0.008003  0.009791
DIS    0.005352  0.071514  0.009315  0.001750  0.015920  0.010569
GOOGL  0.011023  0.009315  0.077409 -0.002217  0.006355  0.013982
JNJ    0.004906  0.001750 -0.002217  0.023668  0.010143  0.006289
BAC    0.008003  0.015920  0.006355  0.010143  0.056120  0.011909
CSCO   0.009791  0.010569  0.013982  0.006289  0.011909  0.040735
Optimal Weight Allocation: [8.81347266e-03 7.47089755e-02 1.94493022e-01 9.63804193e-16
 0.00000000e+00 1.41088943e-01 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.54585491e-15 2.60714256e-01 9.01504823e-16
 0.00000000e+00 3.20181330e-01 1.34258404e-16 3.77115083e-16
 0.00000000e+00 1.81333747e-15 8.35514547e-16 0.00000000e+00]
Expected Annual Return: 0.30840545314632173
Annual Volatility: 0.12115563550499585
Sharpe Ratio: 2.1328389064961524
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