Instructions:
Be verbose. Explain clearly your reasoning, methods, and results in your written work.

No code is necessary, but including it in your answer could result in partial credit.

Written answers are worth the amounts stated.

Total available points on this exam is 50. That means there are 10 points of extra credit available.

1. Answers should be formatted as a PDF. You may convert your Python notebook, if you use one, directly to PDF.
2. Restate the question along with the question number before each answer
3. When finished, email your PDF directly to me along with your code.
4. Do not check code or answers into your repository until after the exam is completed by all.

Data for problems are available in the repository named by the question number.

You may use your notes and the internet for **coding syntax help only**. You may not work with other students – all work must be your own.

All students will be held to the Duke Community Standard

Duke's Community Standard:

Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and non-academic endeavors, and to protect and promote a culture of integrity.
To uphold the Duke Community Standard:

1. I will not lie, cheat, or steal in my academic endeavors,
2. I will conduct myself honorably in all my endeavors; and
3. I will act if the Standard is compromised.

1. (5 pts) Explain the difference in thinking between data modeling for risk analysis vs data modeling for forecasting.

2. (5pts) Using problem2.csv
    a. Calculate the Mean, Variance, Skewness and Kurtosis of the data (2)
    b. Given a choice between a normal distribution and a t-distribution, which one would you choose to model the data and why based on part a alone (1)?
    c. Fit both distributions and prove or disprove your choice in b. (2)

3. (5pts) Using problem3.csv
    a. Calculate the pairwise covariance matrix of the data. (1)
    b. Is the matrix at least positive semi-definite? Why? (2)
    c. If not, find the nearest positive semi-definite matrix using Higham's method as defined in the notes. (2)

4. (5pts) Using problem4.csv – Calculate the exponentially weighted covariance matrix with lambda = 0.94. Assume the data are normally distributed with 0 mean and this covariance.
    a. What are the risk parity portfolio weights using standard deviation as your risk measure? (3)
    b. What are the risk parity portfolio weights using expected shortfall as your risk measure? (2)

5. (10 pts) You own a portfolio of 3 assets with the following starting weights (0.3, 0.2, 0.5). The returns of each asset for 30 days (after the starting weights are calculated) are in problem5.csv. You do not rebalance your portfolio during this 30 day period.
    a. Calculate the ex-post return contribution of each asset. (5)
    b. Calculate the ex-post risk contribution of each asset. (5)

6. (20 pts). A price time series for 2 assets for the past year are in problem6.csv.
    a. Assumptions
        i. Use arithmetic returns for your models
        ii. Assume 0 mean returns for each asset going forward.
        iii. The current risk free rate is 4.75%
        iv. There are 252 trading days in a year.
        v. The current implied volatility of options is constant.
        vi. Report VaR and a $ value and at the 5% level.
    b. Portfolio
        i. 100 Shares of stock A
        ii. 100 American Put options on Stock A
            1. Strike = 100
            2. TTM = 1 year
            3. Implied Vol = 20%
            4. Dividend of 0.025 is paid 60 and 220 days from current.
        iii. 50 Shares of stock B
        iv. -50 (you are short) European Call Options on Stock B
            1. Strike=100
            2. Current Call Price = $6.50
            3. TTM = 100 days
            4. The stock does not pay dividends.
    c. Using a delta normal approach, calculate the 1 day VaR and ES of the portfolio (5)
    d. Using a Monte Carlo simulation and assuming multivariate normality, calculate the 1 day VaR and ES of the portfolio. (5)
    e. Using the best fit model for each asset (choose between a normal and a t-distribution), calculate VaR and ES for the portfolio. (5)
    f. Compare and contrast the results of a, b, and C. Which would you choose to use and why? (5)