```
% Load the dataset
data = readtable('C:\Users\OMBATI\Documents\HW3data.csv');
returns = data{:, 2:end}; % Extract returns data

% Display the first 10 rows and last 10 rows of the data
fprintf('First 10 Rows of Dataset:\n');
```

```
First 10 Rows of Dataset:
```

```
disp(data(1:10, :));
```

Date	Cnsmr	Manuf	HiTec	Hlth	Other
1.9261e+05	0.0543	0.0273	0.0183	0.0177	0.0213
1.9261e+05	0.0276	0.0233	0.0241	0.0425	0.0435
1.9261e+05	0.0216	-0.0044	0.0106	0.0069	0.0029
1.9261e+05	-0.039	-0.0242	-0.0226	-0.0057	-0.0284
1.9261e+05	0.037	0.025	0.0307	0.0542	0.0211
1.9261e+05	0.0362	0.0276	0.0103	0.0011	0.0347
1.927e+05	-0.0119	0.0015	0.0046	0.0505	0.015
1.927e+05	0.0528	0.04	0.0419	0.0171	0.0505
1.927e+05	0.0164	-0.0143	0.0365	0.0101	0.0122
1.927e+05	0.0352	-0.0113	0.0135	0.0274	0.0083

```
fprintf('Last 10 Rows of Dataset:\n');
```

```
Last 10 Rows of Dataset:
```

```
disp(data(end-9:end, :));
```

Date	Cnsmr	Manuf	HiTec	Hlth	Other
2.0221e+05	-0.0762	-0.1095	-0.1161	-0.0191	-0.0791
2.0221e+05	0.0386	0.1346	0.0532	0.0884	0.116
2.0221e+05	0.0246	0.0624	0.0499	0.0546	0.06
2.0221e+05	-0.0936	-0.0257	-0.0777	-0.0173	-0.0527
2.023e+05	0.0908	0.0365	0.101	-0.0102	0.0708
2.023e+05	-0.0199	-0.039	-0.0075	-0.043	-0.026
2.023e+05	0.0273	0.0087	0.0952	0.0253	-0.046
2.023e+05	-0.0011	0.0071	0.0038	0.0408	0.0206
2.0231e+05	0.0048	-0.0673	0.0695	-0.0377	-0.0273
2.0231e+05	0.0896	0.0797	0.0586	0.0466	0.0737

```
% Part (1a): (a) Compute the annualized expected returns and covariance matrix. (Hint: Estimate
nMonths = size(returns, 1);
nAssets = size(returns, 2);
annualReturns = mean(returns) * 12;
covarianceMatrix = cov(returns) * 12;

% Display results of Part (1a)
fprintf('Part (1a) - Annualized Expected Returns:\n');
```

```
Part (1a) - Annualized Expected Returns:
```

```
disp(annualReturns);
```

```
    0.1211    0.1152    0.1189    0.1291    0.1093
```

```
fprintf('Part (1a) - Covariance Matrix:\n');
```

```
Part (1a) - Covariance Matrix:
```

```
disp(covarianceMatrix);
```

```
    0.0335    0.0303    0.0289    0.0271    0.0354
    0.0303    0.0365    0.0296    0.0272    0.0378
    0.0289    0.0296    0.0375    0.0261    0.0341
    0.0271    0.0272    0.0261    0.0366    0.0312
    0.0354    0.0378    0.0341    0.0312    0.0491
```

```
% Part (1b): Find MVE portfolio weights and Sharpe Ratio
riskFreeRate = 0.03;
rfPortfolioWeights = (annualReturns - riskFreeRate) ./ (covarianceMatrix * ones(nAssets, 1));
rfPortfolioWeights = rfPortfolioWeights / sum(rfPortfolioWeights);
rfPortfolioReturn = rfPortfolioWeights' * annualReturns';
rfPortfolioRisk = sqrt(rfPortfolioWeights' * covarianceMatrix * rfPortfolioWeights);
rfSharpeRatio = (rfPortfolioReturn - riskFreeRate) / rfPortfolioRisk;

% Display results of Part (1b)
fprintf('Part (1b) - Risk-Free Portfolio Weights:\n');
```

```
Part (1b) - Risk-Free Portfolio Weights:
```

```
disp(rfPortfolioWeights);
```

```
    0.2070
    0.1991
    0.2056
    0.2170
    0.1713
```

```
fprintf('Part (1b) - Risk-Free Portfolio Return: %.4f\n', rfPortfolioReturn);
```

```
Part (1b) - Risk-Free Portfolio Return: 0.1192
```

```
fprintf('Part (1b) - Risk-Free Portfolio Risk: %.4f\n', rfPortfolioRisk);
```

```
Part (1b) - Risk-Free Portfolio Risk: 0.1787
```

```
fprintf('Part (1b) - Risk-Free Portfolio Sharpe Ratio: %.4f\n', rfSharpeRatio);
```

```
Part (1b) - Risk-Free Portfolio Sharpe Ratio: 0.4991
```

```
% Part (c): You have been hired to manage the portfolio of a mean-variance investor with a coef
gamma = 3;
Aeq = ones(1, nAssets);
beq = 1;
lb = zeros(nAssets, 1);
ub = ones(nAssets, 1);
mvPortfolioWeights = quadprog(gamma * covarianceMatrix, [], [], [], Aeq, beq, lb, ub);
```

```
Minimum found that satisfies the constraints.
```

```
Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
```

```
mvPortfolioReturn = mvPortfolioWeights' * annualReturns';
mvPortfolioRisk = sqrt(mvPortfolioWeights' * covarianceMatrix * mvPortfolioWeights);
mvSharpeRatio = (mvPortfolioReturn - riskFreeRate) / mvPortfolioRisk;

% Display results of Part (1c)
fprintf('Part (1c) - Mean-Variance Efficient Portfolio Weights:\n');
```

```
Part (1c) - Mean-Variance Efficient Portfolio Weights:
```

```
disp(mvPortfolioWeights);
```

```
    0.3203
    0.1351
    0.2175
    0.3271
    0.0000
```

```
fprintf('Part (1c) - Mean-Variance Efficient Portfolio Return: %.4f\n', mvPortfolioReturn);
```

```
Part (1c) - Mean-Variance Efficient Portfolio Return: 0.1225
```

```
fprintf('Part (1c) - Mean-Variance Efficient Portfolio Risk: %.4f\n', mvPortfolioRisk);
```

```
Part (1c) - Mean-Variance Efficient Portfolio Risk: 0.1731
```

```
fprintf('Part (1c) - Mean-Variance Efficient Portfolio Sharpe Ratio: %.4f\n', mvSharpeRatio);
```

```
Part (1c) - Mean-Variance Efficient Portfolio Sharpe Ratio: 0.5340
```

```
% Part (1d): How does the Sharpe Ratio in part (b) compare to the one in part (c)? Explain.
fprintf('Part (1d) - Sharpe Ratio for Risk-Free Portfolio (b): %.4f\n', rfSharpeRatio);
```

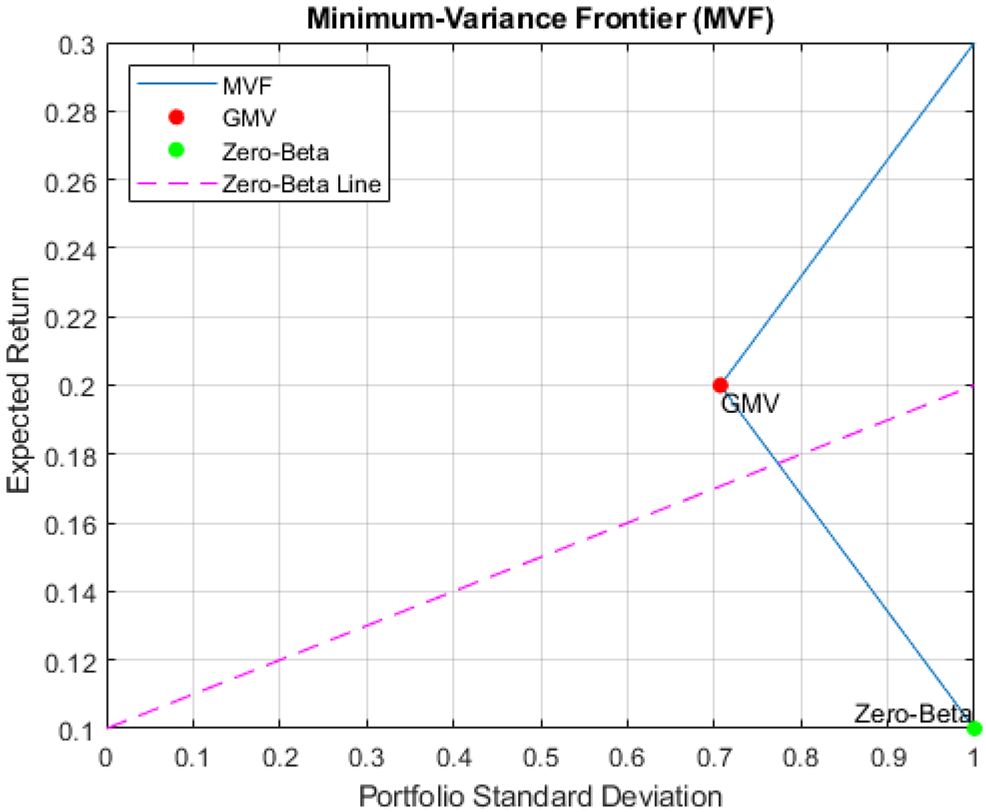
```
Part (1d) - Sharpe Ratio for Risk-Free Portfolio (b): 0.4991
```

```
fprintf('Part (1d) - Sharpe Ratio for Mean-Variance Efficient Portfolio (c): %.4f\n', mvSharpeF
```

```
Part (1d) - Sharpe Ratio for Mean-Variance Efficient Portfolio (c): 0.5340
```

```
% Part 2: The Geometry of the MVF
expectedReturns = [0.10; 0.20; 0.30];
covMatrix = [1 0 0; 0 1 0; 0 0 1];

% (a) Calculate portfolio standard deviation as a function of expected return
nPoints = length(expectedReturns);
portfolios = linspace(0, 1, nPoints);
portStdDeviations = sqrt(portfolios.^2 * (covMatrix(1, 1)) + (1 - portfolios).^2 * (covMatrix(2
    2 * portfolios .* (1 - portfolios) * (covMatrix(1, 2)));

% (b) Plot the MVF
figure;
plot(portStdDeviations, expectedReturns);
```

```
xlabel('Portfolio Standard Deviation');
ylabel('Expected Return');
title('Minimum-Variance Frontier (MVF)');
grid on;


% (2c) Find the global minimum-variance portfolio xGM V .
[~, minVarIdx] = min(portStdDeviations);
xGMV = portfolios(minVarIdx);
rGMV = expectedReturns(minVarIdx);

% (2d) Label the minimum-variance portfolio p' with E[rp' ] = 25% on the MVF you draw in part (
hold on;
scatter(portStdDeviations(minVarIdx), expectedReturns(minVarIdx), 'r', 'filled');
text(portStdDeviations(minVarIdx), expectedReturns(minVarIdx), 'GMV', 'VerticalAlignment', 'top

% (2e) Find a portfolio p'' on the MVF which is uncorrelated with p' and label it on the plot y
zeroBetaPortfolio = [1; -covMatrix(1, 2) / covMatrix(2, 2); 0];
zeroBetaPortfolio = zeroBetaPortfolio / sum(zeroBetaPortfolio);
zeroBetaReturn = zeroBetaPortfolio' * expectedReturns;
zeroBetaStdDev = sqrt(zeroBetaPortfolio' * covMatrix * zeroBetaPortfolio);

% Label zero-beta portfolio on the plot
scatter(zeroBetaStdDev, zeroBetaReturn, 'g', 'filled');
text(zeroBetaStdDev, zeroBetaReturn, 'Zero-Beta', 'HorizontalAlignment', 'right', 'VerticalAlig

% (2f)  Now draw a straight line that passes through (0, rp'' ) and (σp' , rp' ). What do you f
line([0, zeroBetaStdDev], [zeroBetaReturn, expectedReturns(minVarIdx)], 'Color', 'm', 'LineStyl
legend('MVF', 'GMV', 'Zero-Beta', 'Zero-Beta Line', 'Location', 'northwest');
```




```
% Part 3: Implementing MPT with Portfolio Constraints

% Given data
riskFreeRate = 0.01; % Risk-free rate is 1%
assetReturns = [0.08; 0.037; 0.06];
assetVolatility = [0.19; 0.25; 0.15];
correlationMatrix = [1 0.5 0.8; 0.5 1 0.2; 0.8 0.2 1];
gamma = 2; % Coefficient of risk aversion

% Part (3a): Compute the MVE portfolio weights and the Sharpe Ratio in the absence of portfolio
Aeq = ones(1, 3);
beq = 1;
lb = zeros(3, 1);
ub = [];
mvePortfolioWeights = quadprog(gamma * correlationMatrix, [], [], [], Aeq, beq, lb, ub);
```

```
Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
```

```
mvePortfolioReturn = mvePortfolioWeights' * assetReturns;
mvePortfolioRisk = sqrt(mvePortfolioWeights' * correlationMatrix * mvePortfolioWeights);
mveSharpeRatio = (mvePortfolioReturn - riskFreeRate) / mvePortfolioRisk;
```

```
% Display results of Part (3a)
fprintf('Part (3a) - MVE Portfolio Weights:\n');
```

```
Part (3a) - MVE Portfolio Weights:
```

```
disp(mvePortfolioWeights);
```

```
    0.0000
    0.5000
    0.5000
```

```
fprintf('Part (3a) - MVE Portfolio Return: %.4f\n', mvePortfolioReturn);
```

```
Part (3a) - MVE Portfolio Return: 0.0485
```

```
fprintf('Part (3a) - MVE Portfolio Risk: %.4f\n', mvePortfolioRisk);
```

```
Part (3a) - MVE Portfolio Risk: 0.7746
```

```
fprintf('Part (3a) - MVE Portfolio Sharpe Ratio: %.4f\n', mveSharpeRatio);
```

```
Part (3a) - MVE Portfolio Sharpe Ratio: 0.0497
```

```
% Part (3b):  Now impose a no short-sales constraint (i.e., the portfolio weight in each asset
bindingAsset = find(mvePortfolioWeights == max(mvePortfolioWeights));

% Display result of Part (3b)
fprintf('Part (3b) - Asset with Binding Constraint: Asset %d\n', bindingAsset);
```

```
Part (3b) - Asset with Binding Constraint: Asset 2
```

```
% Part (3c):  Now impose a no short-sales constraint (i.e., the portfolio weight in each asset
lb(bindingAsset) = 0;
ub = ones(3, 1);
constrainedMVEPortfolioWeights = quadprog(gamma * correlationMatrix, [], [], [], Aeq, beq, lb,
```

```
Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
```

```
constrainedMVEPortfolioReturn = constrainedMVEPortfolioWeights' * assetReturns;
constrainedMVEPortfolioRisk = sqrt(constrainedMVEPortfolioWeights' * correlationMatrix * constr
constrainedMVESharpeRatio = (constrainedMVEPortfolioReturn - riskFreeRate) / constrainedMVEPort

% Display results of Part (3c)
fprintf('Part (3c) - Constrained MVE Portfolio Weights:\n');
```

```
Part (3c) - Constrained MVE Portfolio Weights:
```

```
disp(constrainedMVEPortfolioWeights);
```

```
    0.0000
    0.5000
    0.5000
```

```
fprintf('Part (3c) - Constrained MVE Portfolio Return: %.4f\n', constrainedMVEPortfolioReturn);
```

```
Part (3c) - Constrained MVE Portfolio Return: 0.0485
```

```
fprintf('Part (3c) - Constrained MVE Portfolio Risk: %.4f\n', constrainedMVEPortfolioRisk);
```

```
Part (3c) - Constrained MVE Portfolio Risk: 0.7746
```

```
fprintf('Part (3c) - Constrained MVE Portfolio Sharpe Ratio: %.4f\n', constrainedMVESharpeRatio
```

```
Part (3c) - Constrained MVE Portfolio Sharpe Ratio: 0.0497
```

```
% Part 3, Question (d): Calculate optimal portfolio weights for a mean-variance investor with γ
gamma = 2;

% constraints
Aeq = ones(1, 3);
beq = 1;
lb = zeros(3, 1);
ub = ones(3, 1);

% optimal portfolio weights
optimalPortfolioWeights = quadprog(gamma * correlationMatrix, [], [], [], Aeq, beq, lb, ub);
```

```
Minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
```

```
% portfolio statistics
optimalPortfolioReturn = optimalPortfolioWeights' * assetReturns;
optimalPortfolioRisk = sqrt(optimalPortfolioWeights' * correlationMatrix * optimalPortfolioWeig
optimalPortfolioSharpeRatio = (optimalPortfolioReturn - riskFreeRate) / optimalPortfolioRisk;

% Display results
fprintf('Part (3d) - Optimal Portfolio Weights:\n');
```

```
Part (3d) - Optimal Portfolio Weights:
```

```
disp(optimalPortfolioWeights);
```

```
    0.0000
    0.5000
    0.5000
```

```
fprintf('Part (3d) - Optimal Portfolio Return: %.4f\n', optimalPortfolioReturn);
```

```
Part (3d) - Optimal Portfolio Return: 0.0485
```

```
fprintf('Part (3d) - Optimal Portfolio Risk: %.4f\n', optimalPortfolioRisk);
```

```
Part (3d) - Optimal Portfolio Risk: 0.7746
```

```
fprintf('Part (3d) - Optimal Portfolio Sharpe Ratio: %.4f\n', optimalPortfolioSharpeRatio);
```

```
Part (3d) - Optimal Portfolio Sharpe Ratio: 0.0497
```