भारतीय प्रौद्योगिकी संस्थान गुवाहाटी
INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

MA 374: Financial Engineering Lab

Lab 04

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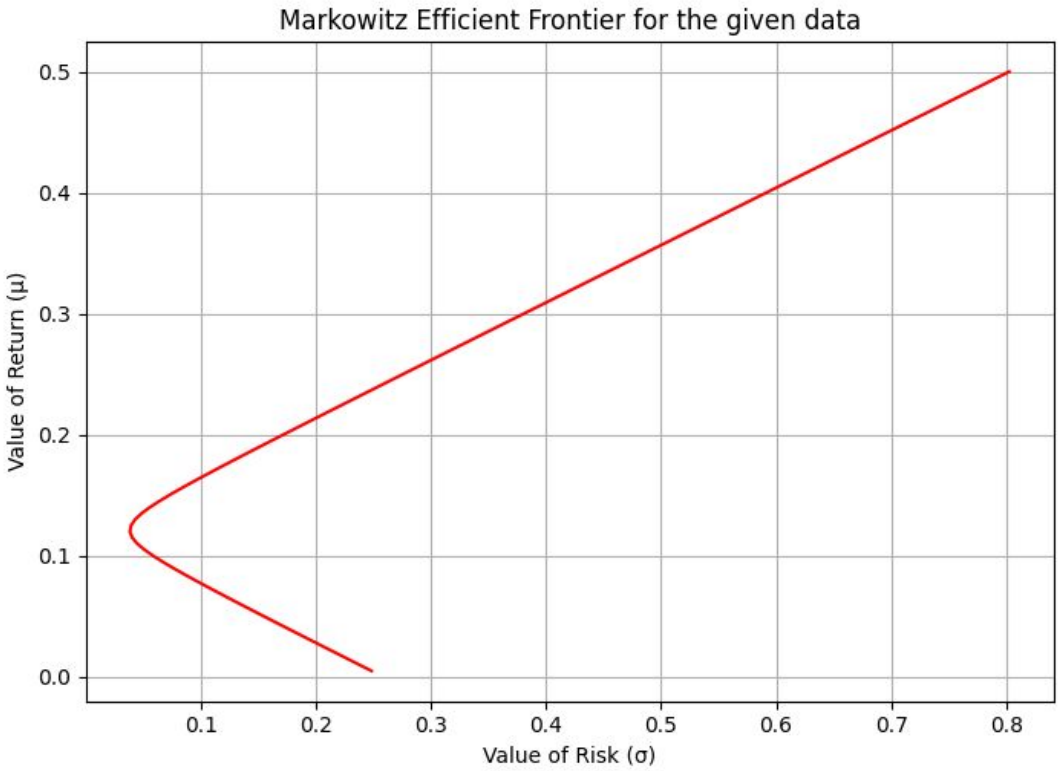
Note: ✍

1. *For **question 2** please wait patiently (~10 s) for the first graph since I have used **100000** data-points for depicting the feasible region.*
2. ***Please run python programs using python3**, i.e.* `python3 <filename>.py`

Question 1.

(a)



The plot shows the Markowitz efficient frontier constructed using the data:

$M = [0.1 \quad 0.2 \quad 0.15]$

$$C = \begin{bmatrix} 0.005 & -0.010 & 0.004 \\ -0.010 & 0.040 & -0.002 \\ 0.004 & -0.002 & 0.023 \end{bmatrix}$$

In constructing the efficient frontier as shown above no restrictions were put on short selling. As a result, the weights of individual assets could be negative. First, 100 points were chosen in the range $[0, 0.5]$, and then these were taken as the returns. Corresponding to the returns, the minimum possible risk was computed and plotted.

(b) The table of **weights**, **risk**, and **return** of the portfolios for 10 different values on the efficient frontier are as shown below:

Return	Risk	Weight1	Weight2	Weight3
0.05	0.1550	1.8349	-0.1651	-0.6697
0.10	0.0587	1.1193	0.1193	-0.2385
0.15	0.0724	0.4037	0.4037	0.1927
0.20	0.1714	-0.3119	0.6881	0.6239
0.25	0.2755	-1.0275	0.9725	1.0550
0.30	0.3805	-1.7431	1.2569	1.4862
0.35	0.4859	-2.4587	1.5413	1.9174
0.40	0.5913	-3.1743	1.8257	2.3486
0.45	0.6969	-3.8899	2.1101	2.7798
0.50	0.8025	-4.6055	2.3945	3.2110

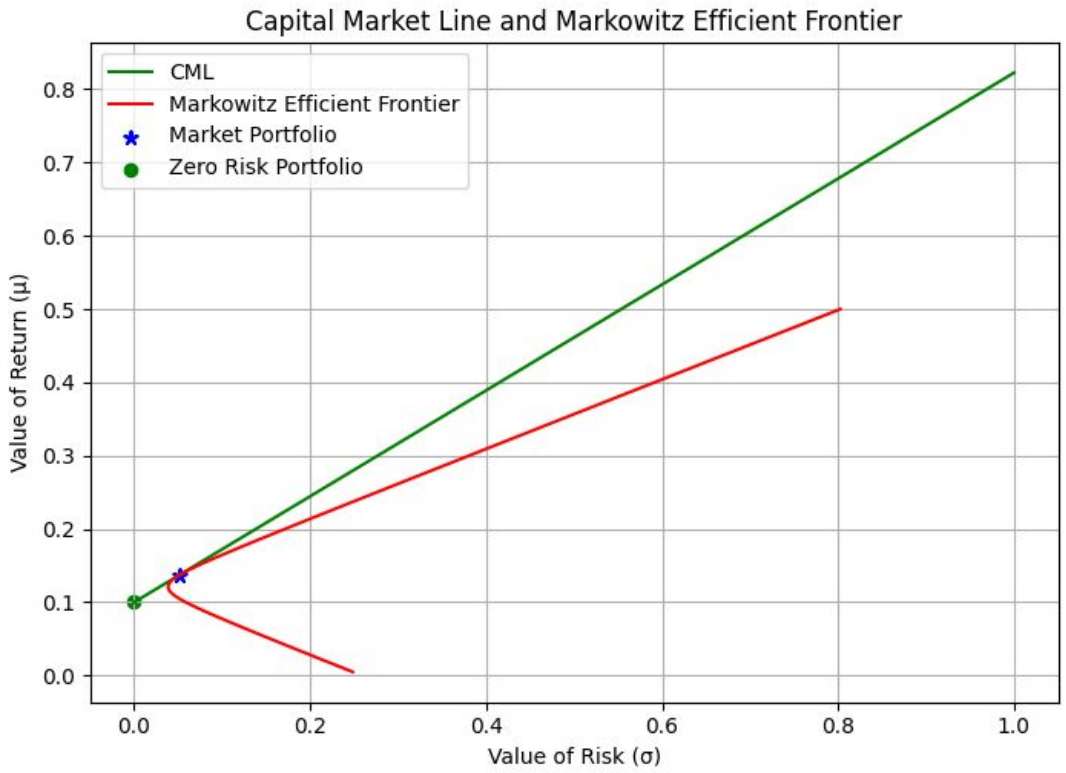
(c) For a 15% risk:

- Maximum Return Portfolio:
  Return = 18.9555% and Weights : -0.1624, 0.6287, 0.5338
- Minimum Return Portfolio:
  Return = 5.2447% and Weights : 1.7998, -0.1512, -0.6486

(d) Minimum Risk Portfolio for 18% return

```
Risk = 13.0568% and Weights : -0.0257,  0.5743,  0.4514
```

(e)



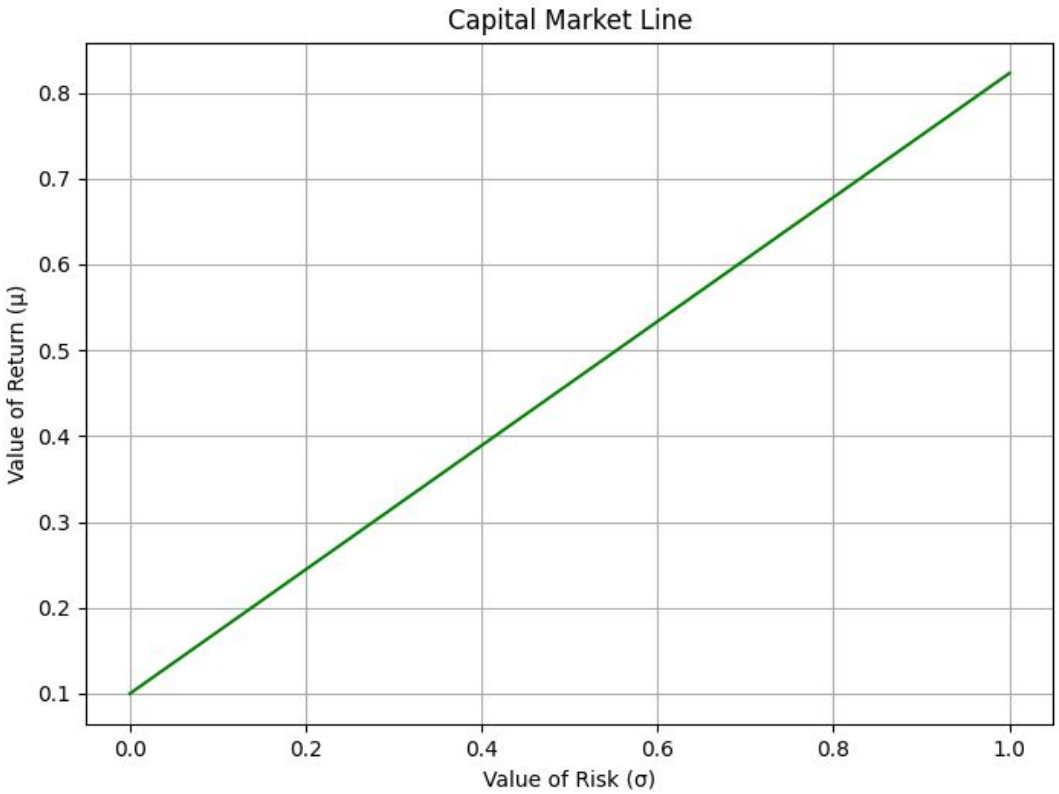
The figure shows the Market Portfolio, CML, Zero-risk Portfolio, and the Markowitz Efficient Frontier.

To get the market portfolio, the point on the Efficient Frontier, which gave the maximum Sharpe Ratio, with the given risk-free return ($\mu_{rf} = 10\%$), was used. The line joining the zero risk portfolio and the market portfolio is the Captial Market Line.

```
The computed market portfolio corresponds to the point
(0.051,0.137), i.e,
```

- `Weights : 0.5938,  0.3281,  0.0781`
- `Return on market portfolio = 13.6719%`
- `Risk on market portfolio = 5.0811%`

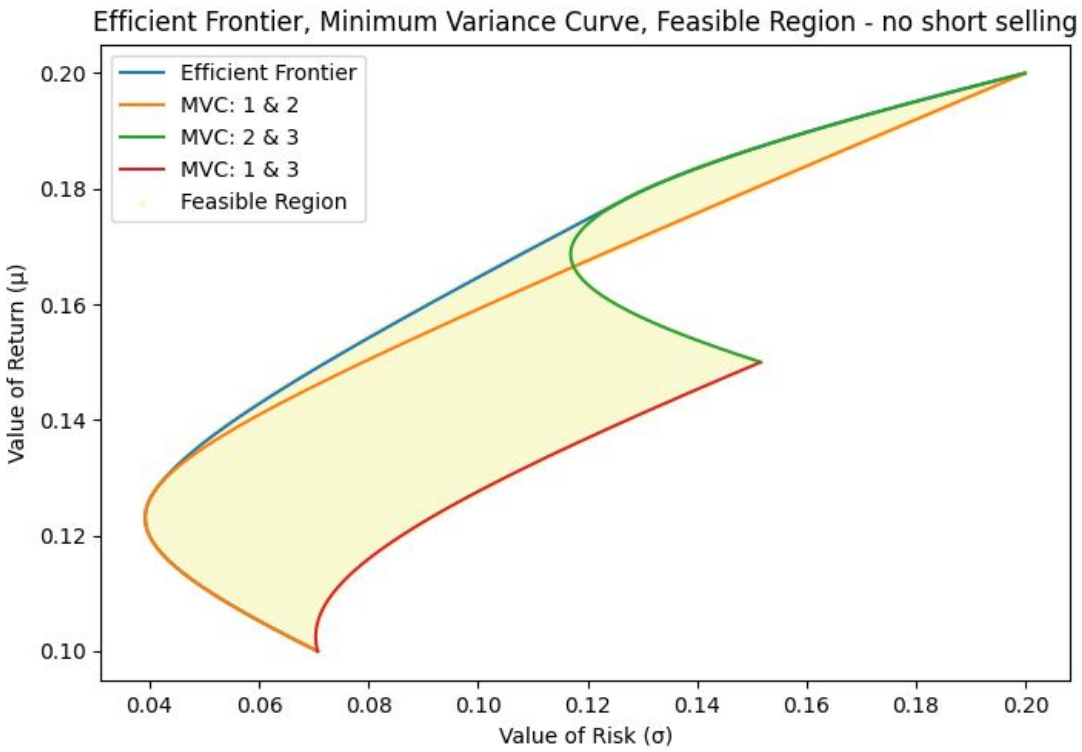
The plot of the CML individually is drawn below:



(f) The 2 portfolios obtained are:

- Portfolio for 10% risk:
  - Risk-Free Asset : -0.9681
  - Risky Assets Weights : 1.1685, 0.6458, 0.1538
- Portfolio for 25% risk:
  - Risk-Free Asset : -3.9202
  - Risky Assets Weights : 2.9213, 1.6144, 0.3844

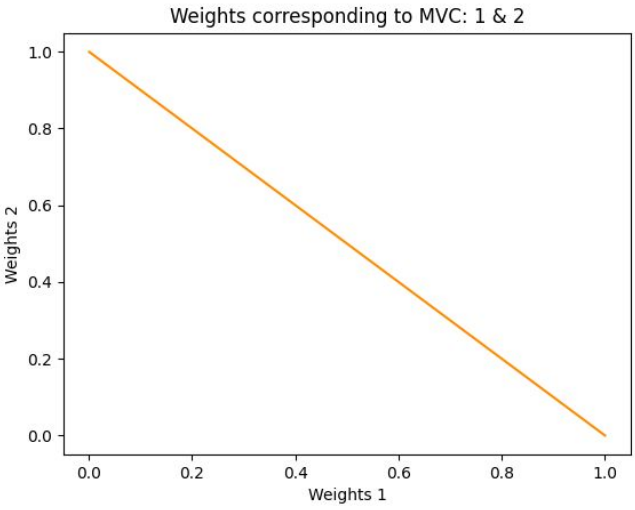
Question 2.

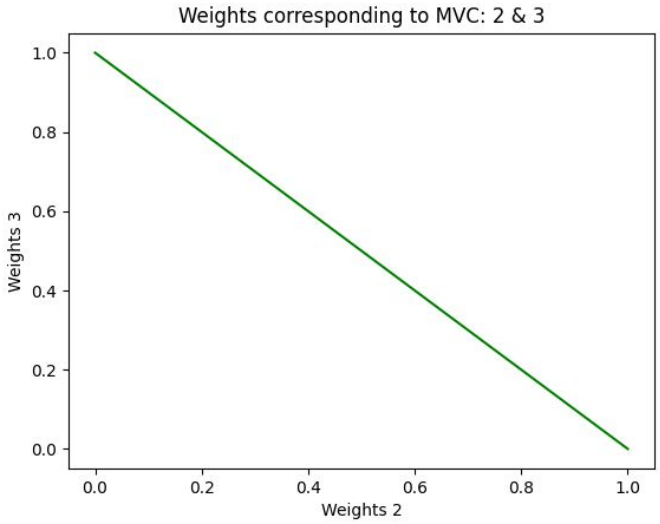


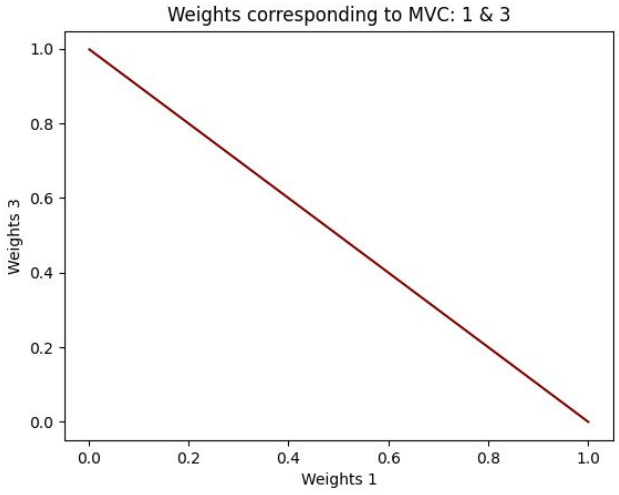
Graph showing efficient frontier, feasible region, and MVCs considering 2 out of 3 securities at a time.

In this question, we used a similar idea as question 1, with the difference that in this case short-selling was not allowed. Thus the weights needed to be strictly in the range $[0, 1]$.

Plots of the weights corresponding to the minimum variance curve are:







As can be easily seen, the equation that these weights satisfy is y=x-1.

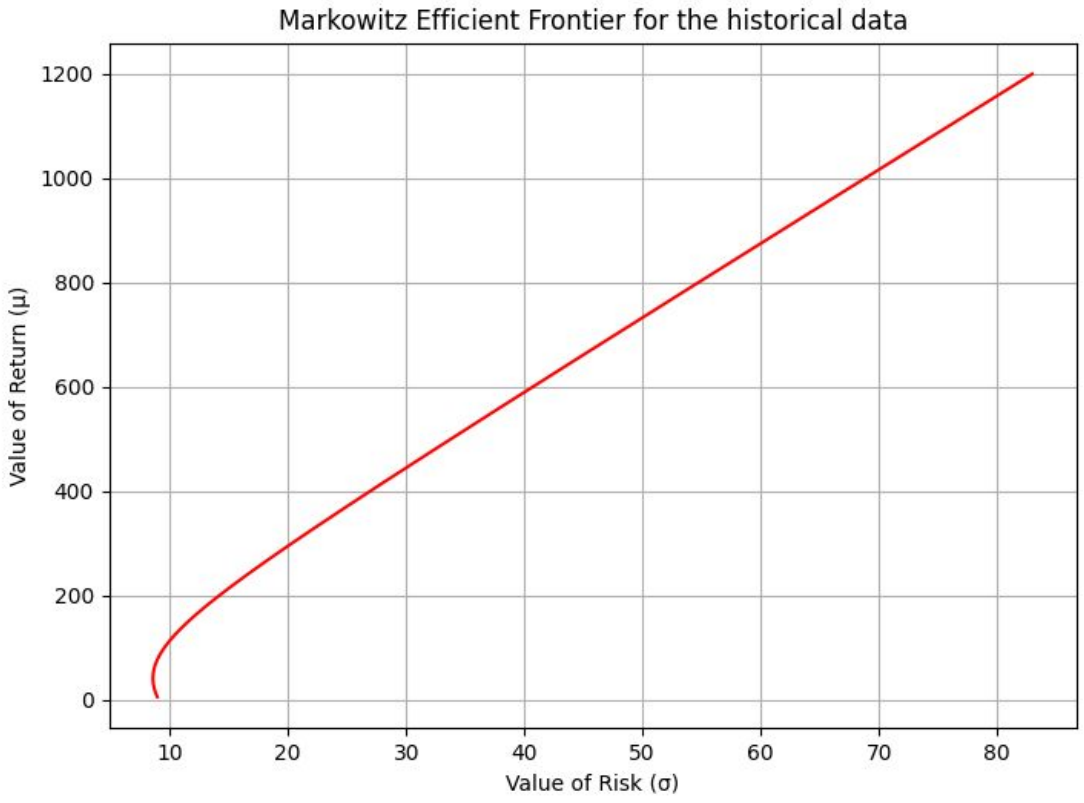
Question 3.

The data of monthly prices were obtained for 10 stocks each with 60 data points all taken at the same duration over 5 years (Feb 01, 2016 - Feb 01, 2021) from https://in.finance.yahoo.com/. The following companies were considered:

```
SBI, Asian Paints, BharatiAirtel, CIPLA, IOC, JSW Steel, Maruti, Wipro, Axis Bank, ONGC
```

Following a similar approach in question 1 after having obtained the Mean Return Vector and Covariance Matrix, we get the following graphs and results.

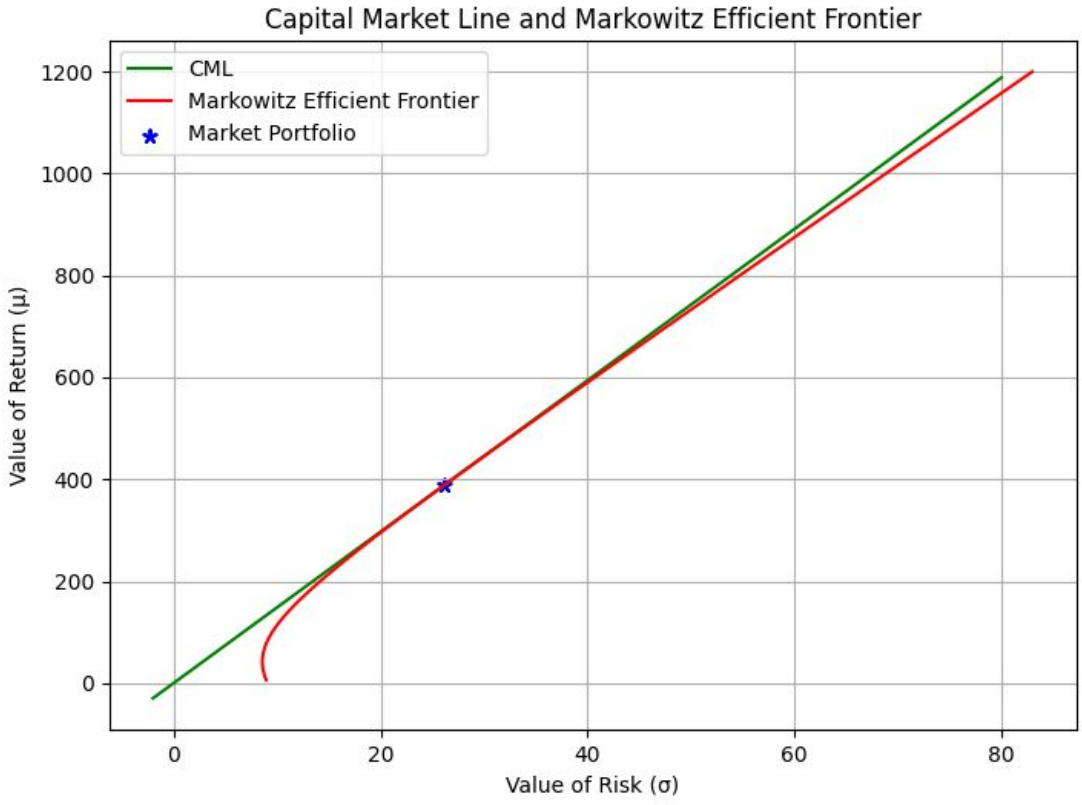
(a)



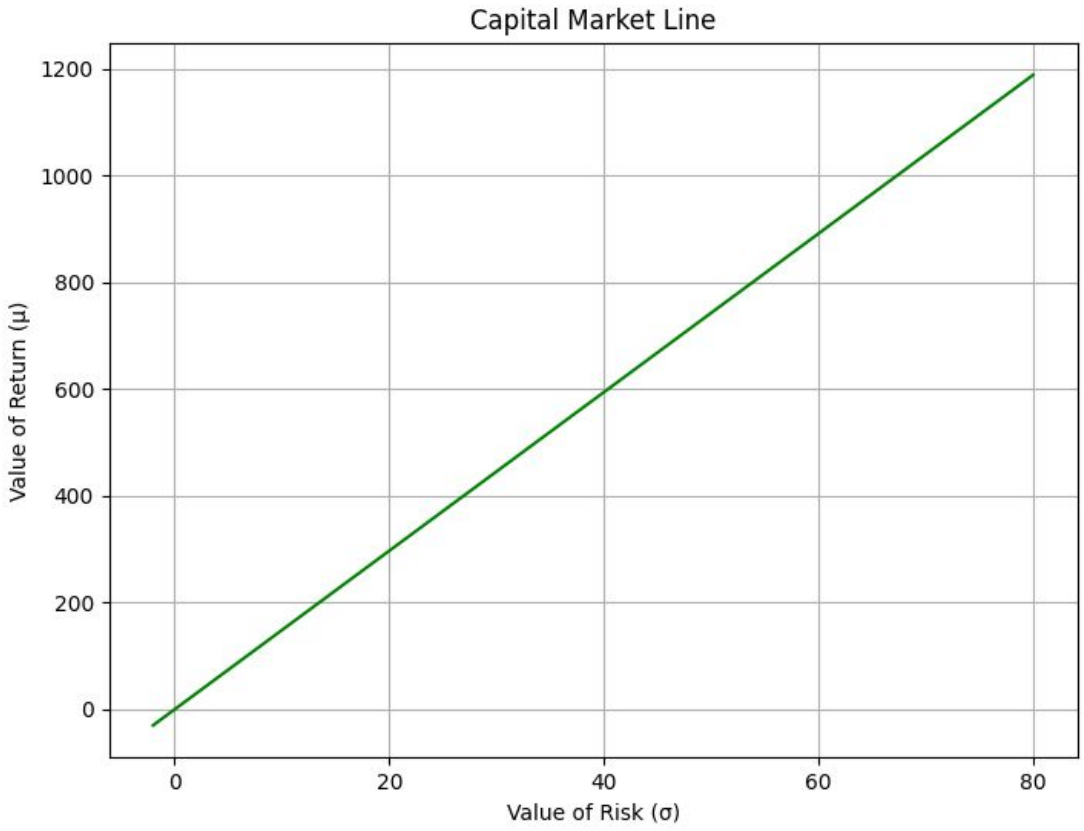
(b) Assuming a 5% risk free return:

- Weights : -0.2859, 0.0371, 0.1714, 0.2898, -0.063, -0.4082, 0.0021, -0.1064, 0.2788, 1.0845
- Return on market portfolio = 38836.9569%
- Risk on market portfolio = 2614.2522%

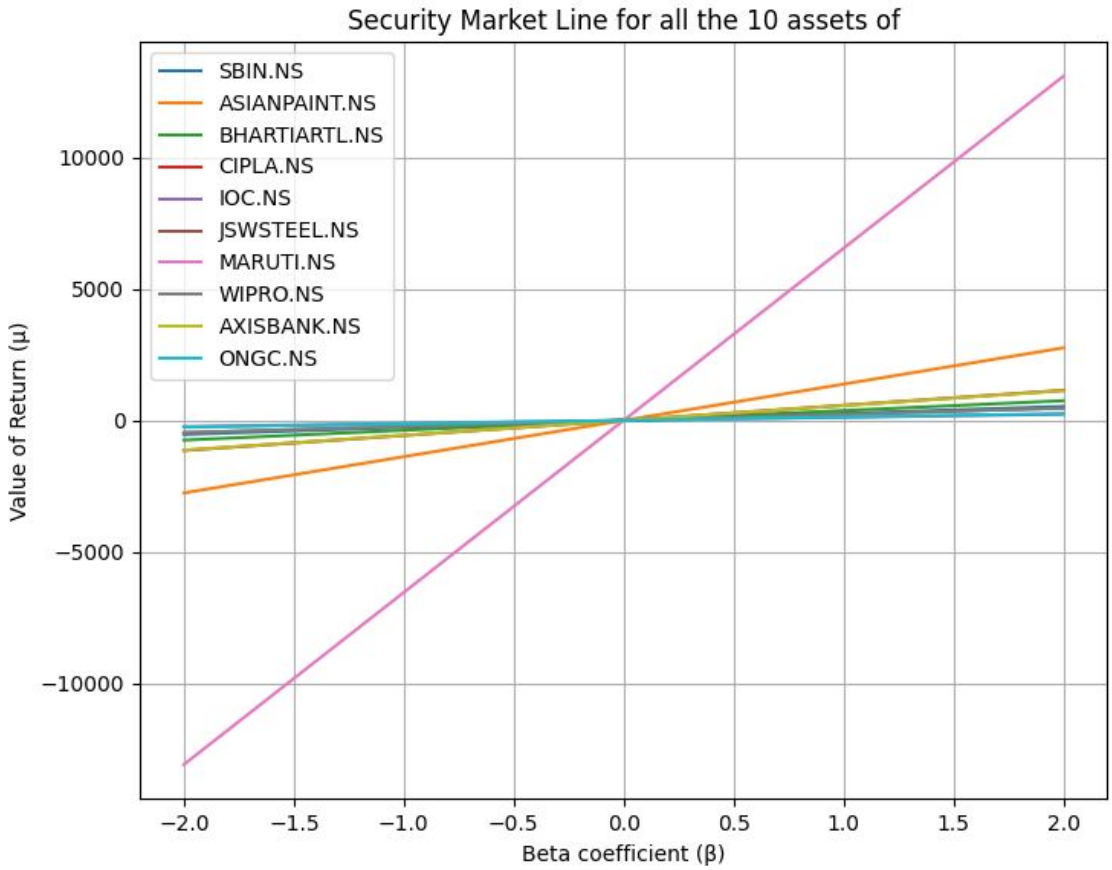
(c)



The plots for the Capital Market Line, Efficient Frontier, and the Market Portfolio are shown above. A plot of only the CML is drawn below.



(c) For plotting the Security Market Line, $E[Ri] = Rf + (E[RM] - Rf)\beta$ was used. Beta was generated uniformly between [-2, 2], and making use of the rest of the values, the Security Market Lines were plotted for all the 10 assets.



Note: For this question, the mean return vector has been obtained by taking the mean of all the columns for the 10 different stocks. The same could also be obtained using $\frac{S()i)-S(i-1)}{S(i)}$ *. The graphs won't change in either case, only the mean return will get scaled.*

Extras...

For this lab, we will need to make use of the following packages. The installation instructions are given alongside.

Kindly use pip3 since the code must be run in python 3 as mentioned previously.

```
Numpy - pip3 install numpy
Matplotlib - pip3 install matplotlib
Scipy - pip3 install scipy
```