MA-374 Lab Assignment 4

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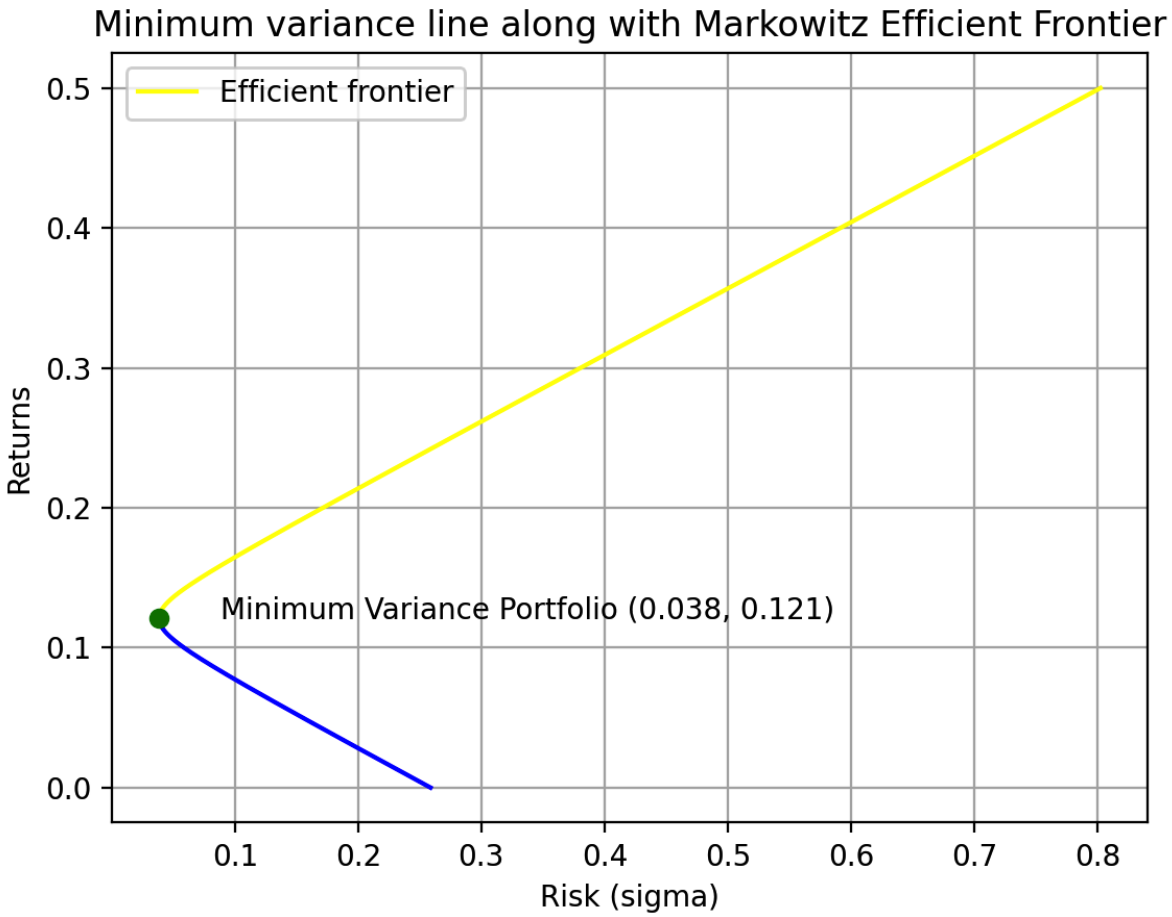
Question 1

The Markowitz Efficient frontier is as follows:



Weights of the portfolio are obtained by the following formula

$$w = \frac{\begin{vmatrix} 1 & uC^{-1}M^T \\ \mu_v & MC^{-1}M^T \end{vmatrix} uC^{-1} + \begin{vmatrix} uC^{-1}u^T & 1 \\ MC^{-1}u^T & \mu_v \end{vmatrix} MC^{-1}}{\begin{vmatrix} uC^{-1}u^T & uC^{-1}M^T \\ MC^{-1}u^T & MC^{-1}M^T \end{vmatrix}}$$

Where uv = return u=[1,1,1,1,1,1…1] (with same dimension as that of number of assets)

The value of σ_v^2 is calculated as per the following formula

$$\sigma_v^2 = wCw^T$$

Taking the square root of that we will get risk of the portfolio. Now, the weights of the minimum variance portfolio is :

$$w = \frac{uC^{-1}}{uC^{-1}u^T}$$

By applying the mentioned formulas, we can determine the specific point on the minimum variance curve. The efficient frontier is characterized by a higher expected return coupled with a lower standard deviation, indicating lower risk. Therefore, points on the curve that exhibit a return greater than that of the minimum variance portfolio point illustrate the efficient frontier, visually depicted in yellow.

b) The weights, return and risk of the portfolios for 10 different values on the efficient frontier:

PART B

For Part B:

Weights	Return	Risk
[[0.23238779 0.47174332 0.2958689]]	0.161968	0.00898428
[[-0.48735321 0.75779423 0.72955899]]	0.212257	0.03873
[[-0.97048555 0.94980836 1.02067719]]	0.246015	0.0713889
[[-1.19138599 1.03760212 1.15378387]]	0.261449	0.0897179
[[-1.3237168 1.09019514 1.23352166]]	0.270696	0.101719
[[-2.17789045 1.42967441 1.74821604]]	0.330378	0.197585
[[-2.23704258 1.45318359 1.78385899]]	0.334511	0.205404
[[-3.06311669 1.7814951 2.2816216]]	0.392231	0.330565
[[-3.10023388 1.7962468 2.30398708]]	0.394824	0.336888
[[-3.10831545 1.79945871 2.30885675]]	0.395389	0.338273

PART C , D , E

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For Part C:

For 15% Risk:

Maximum Return is :  18.95547996080656  %
And the corresponding weights are :  [-0.16243566  0.62866033  0.53377534]

Minimum Return is :  5.244684108102375  %
And the corresponding weights are :  [ 1.79984338 -0.1512198  -0.64862357]

For Part D:

For 18% return:

Minimum Risk is:  0.13056827100982651
And the corresponding weights are :  [-0.02568807  0.57431193  0.45137615]

For Part E:

Market Portfolio Weights =  [0.59375  0.328125 0.078125]
Return =  0.13671875
Risk =  5.081128919221594  %
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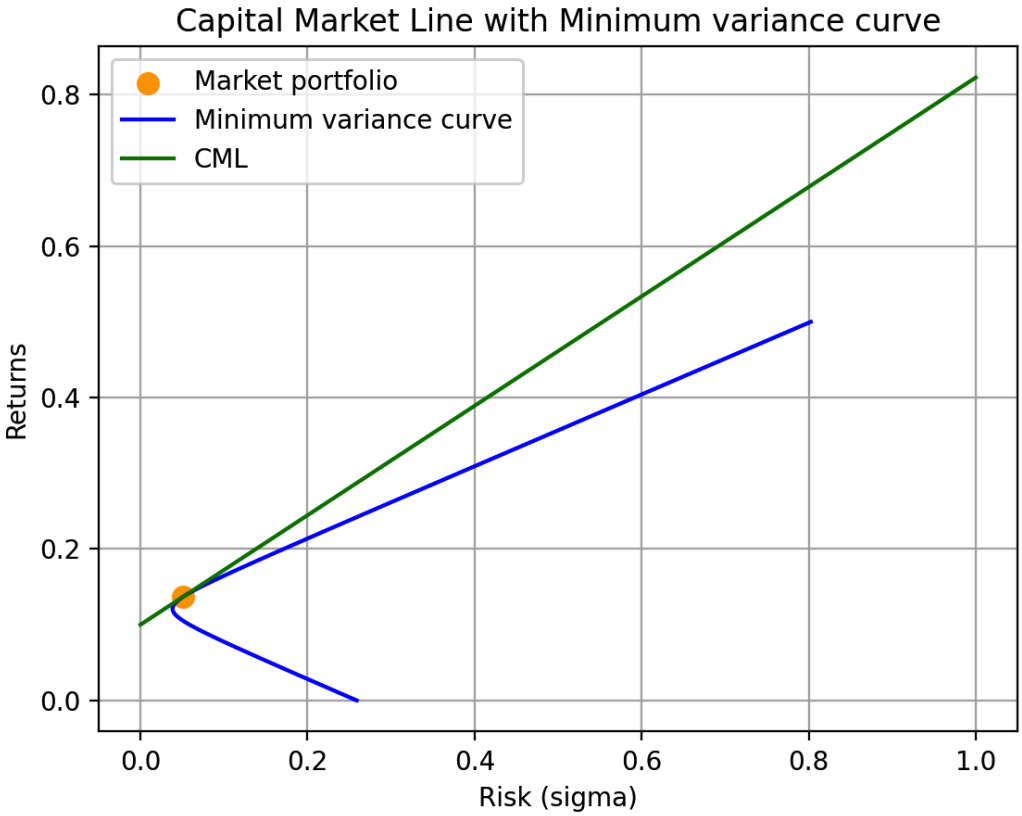


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Equation of CML is:
y = 0.723 x + 0.100
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Which is obtained by the following formula:

$$\mu = \frac{\mu_M - \mu_{rf}}{\sigma_M}\,\sigma + \mu_{rf}$$

where,

μ_M = return corresponding to market portfolio

μ_{rf} = risk free return

σ_M = risk corresponding to market portfolio

PART F

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For Part F:

Risk = 10.0  %
Risk-free weights = -0.9680665771282883
Risky Weights = [1.16853953 0.64577185 0.1537552 ]
Returns= 0.17226494462892933


Risk = 25.0  %
Risk-free weights = -3.920166442820721
Risky Weights = [2.92134883 1.61442961 0.384388  ]
Returns = 0.2806623615723233
(base) arushgupta@depressed-guy Fe2lab %
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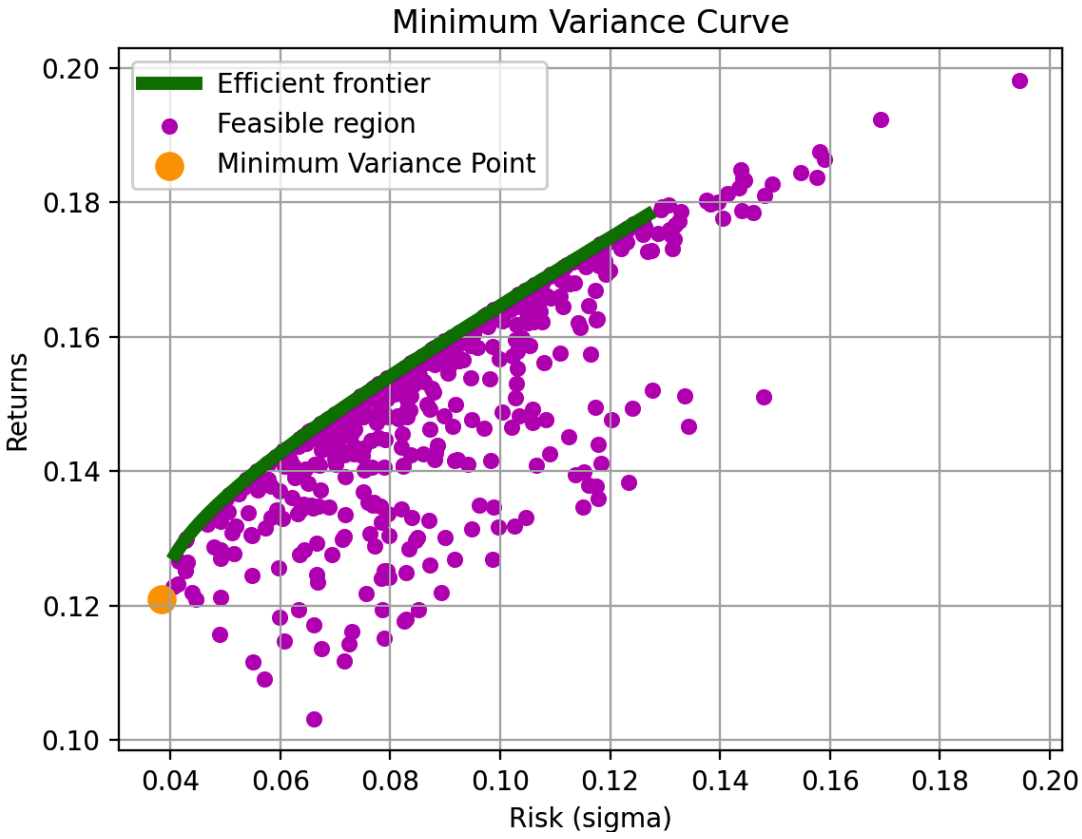
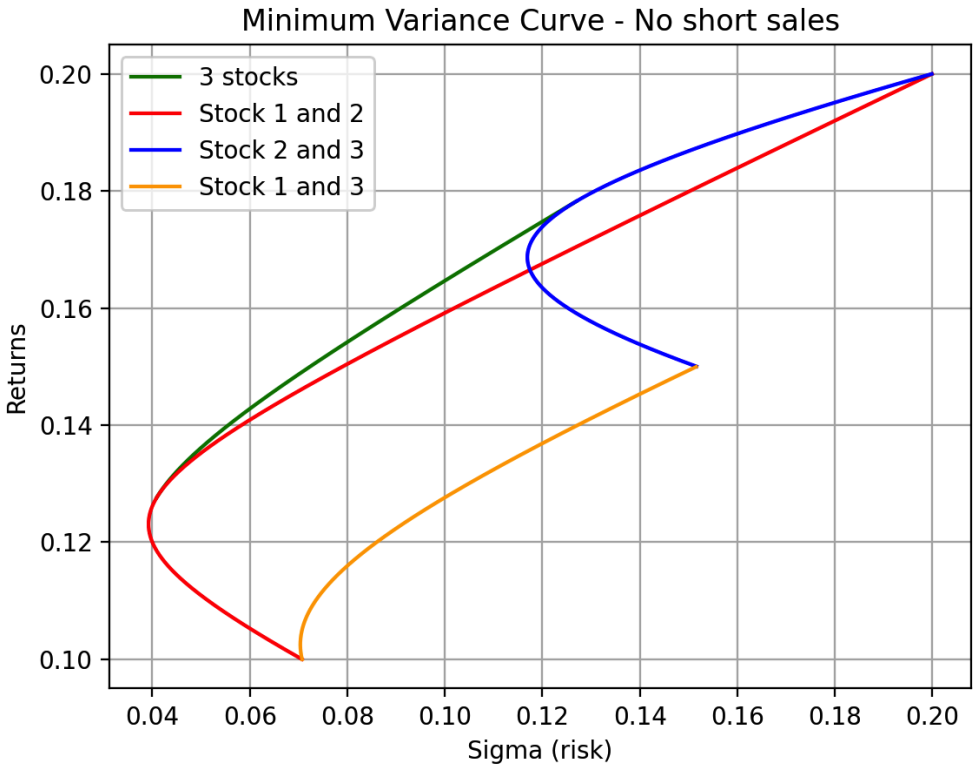
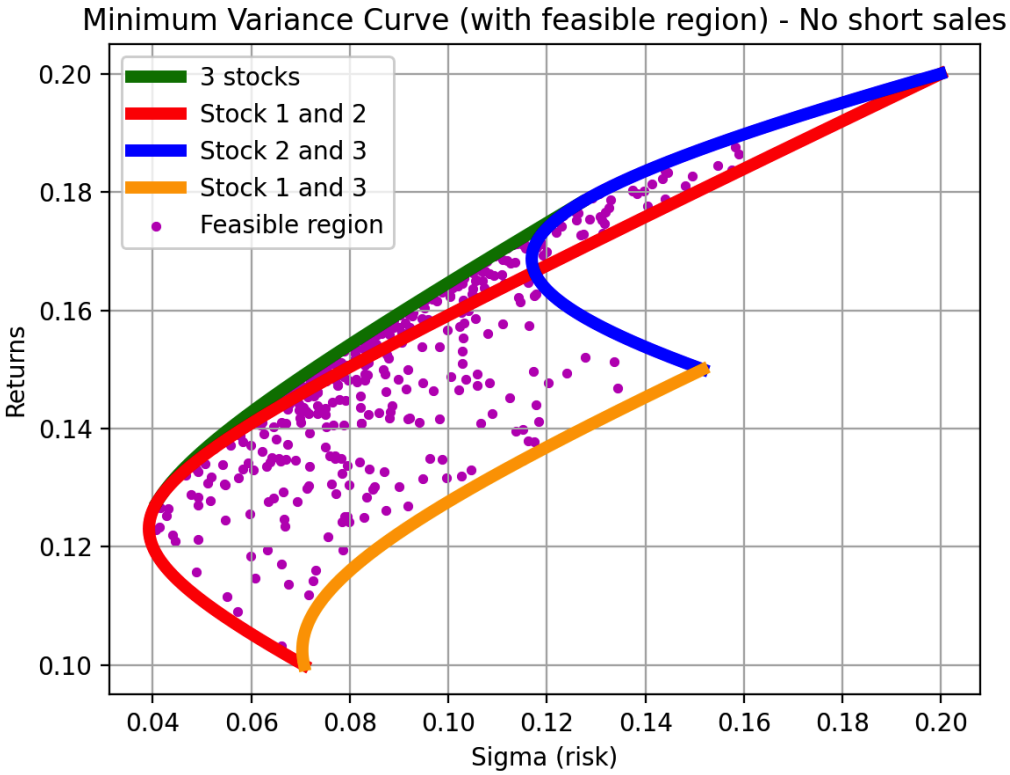
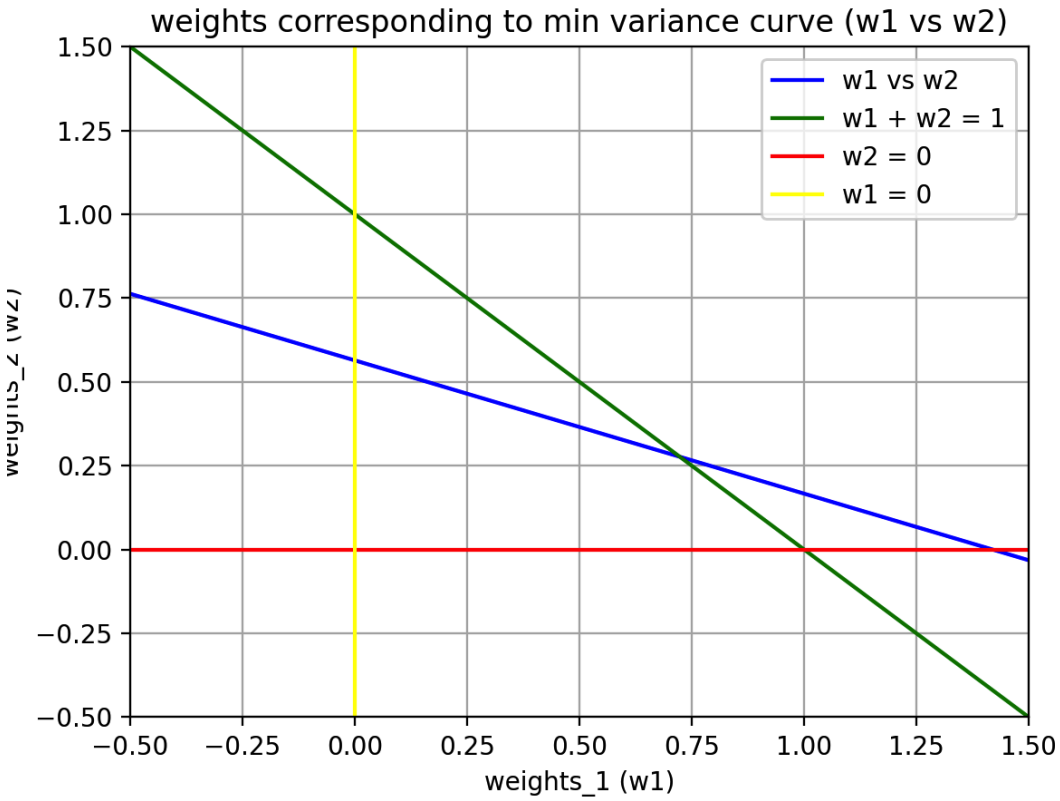
Question 2:

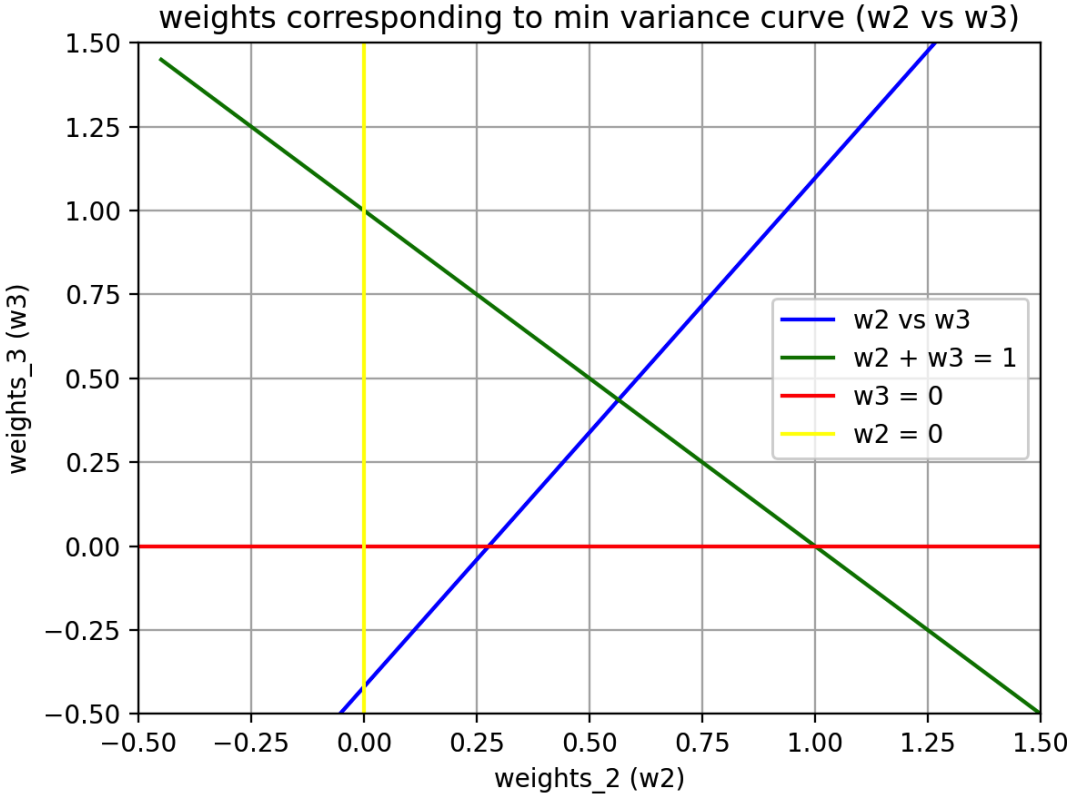
The various plots (assuming short sales are not allowed, i.e. weights are non-negative) are as follows:

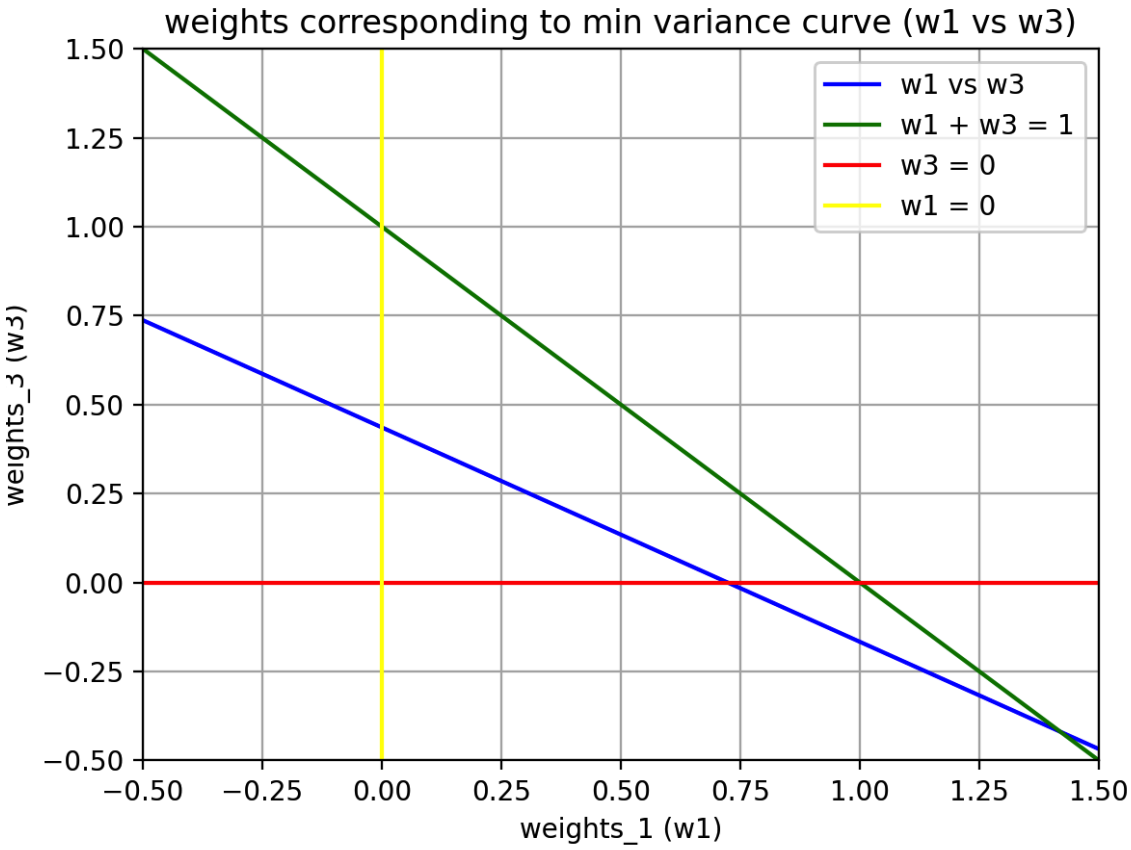



Minimum Variance Curve - No short sales
3 stocks
Stock 1 and 2
Stock 2 and 3
Stock 1 and 3
Returns
Sigma (risk)
0.10
0.12
0.14
0.16
0.18
0.20
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20


Minimum Variance Curve (with feasible region) - No short sales
3 stocks
Stock 1 and 2
Stock 2 and 3
Stock 1 and 3
Feasible region
Returns
Sigma (risk)
0.10
0.12
0.14
0.16
0.18
0.20
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20


weights corresponding to min variance curve (w1 vs w2)
w1 vs w2
w1 + w2 = 1
w2 = 0
w1 = 0
weights_1 (w1)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50


weights corresponding to min variance curve (w2 vs w3)
w2 vs w3
w2 + w3 = 1
w3 = 0
w2 = 0
weights_3 (w3)
weights_2 (w2)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50

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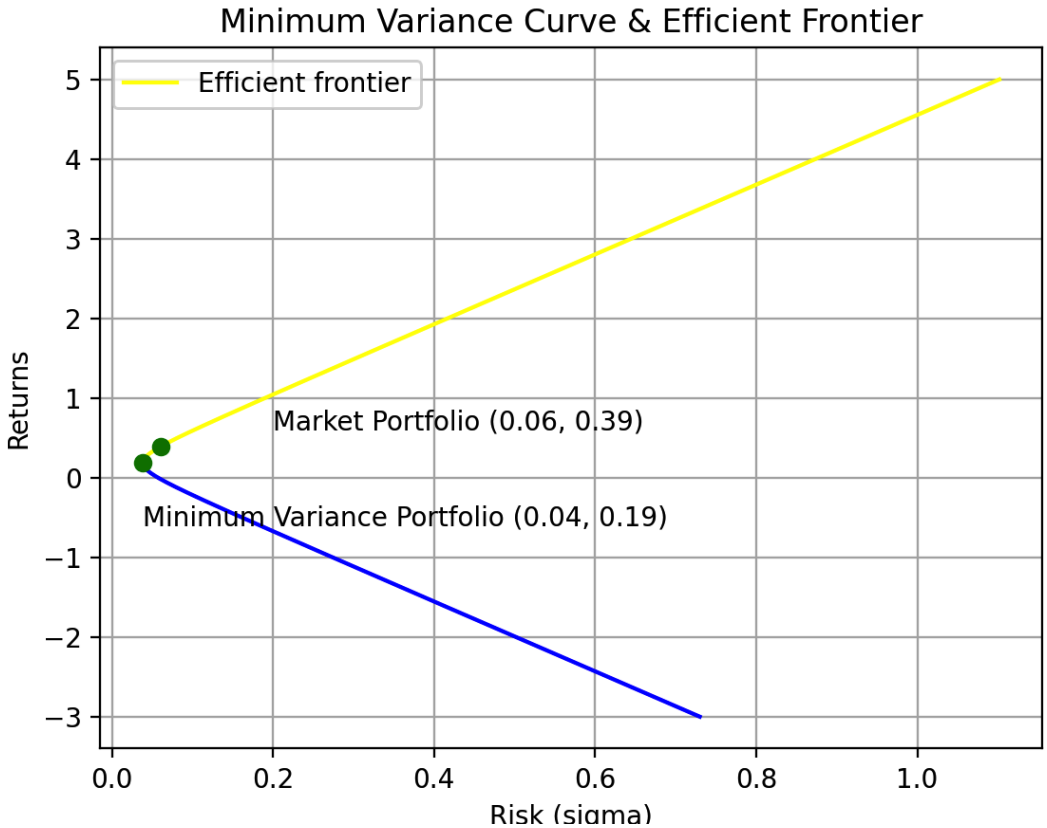
Eqn of line w1 vs w2 is:
w2 = -0.40 w1 + 0.56
Eqn of line w2 vs w3 is:
w3 = 1.52 w2 + -0.42
Eqn of line w1 vs w3 is:
w3 = -0.60 w1 + 0.44
```

Question 3

a) The Markowitz efficient frontier is derived from the data collected for the stocks over a span of 60 months, from 2019-02-01, to 2024-01-01, on a monthly basis. The included companies are AXISBANK,BHARTIARTL,HEROMOTOCO,HINDUNILVR,INFY,MARUTI,RELIANCE,TCS,TITAN,WIPRO. Monthly returns were calculated as the difference in stock prices between the beginning of two consecutive months, and the annual return was subsequently determined.



b)

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==================  sub-part (b) ==================

Market Portfolio Weights        =  [-0.43162424  0.70293127  0.15221988 -0.16212669  0.16217043 -0.12576295
 -0.08275207  0.35114437  0.58890235 -0.15510236]
Return                          =  0.39316362410165673
Risk                            =  6.094840254164253  %
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c)

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Equation of CML is:
y = 5.63 x + 0.05
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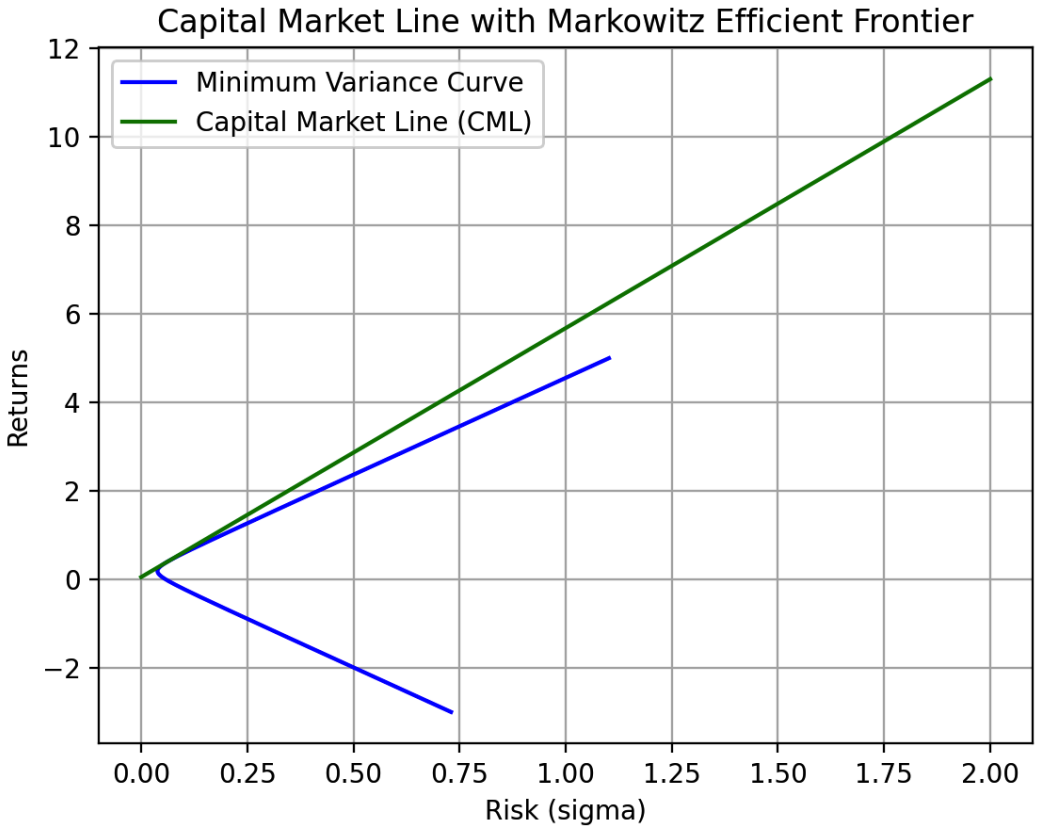
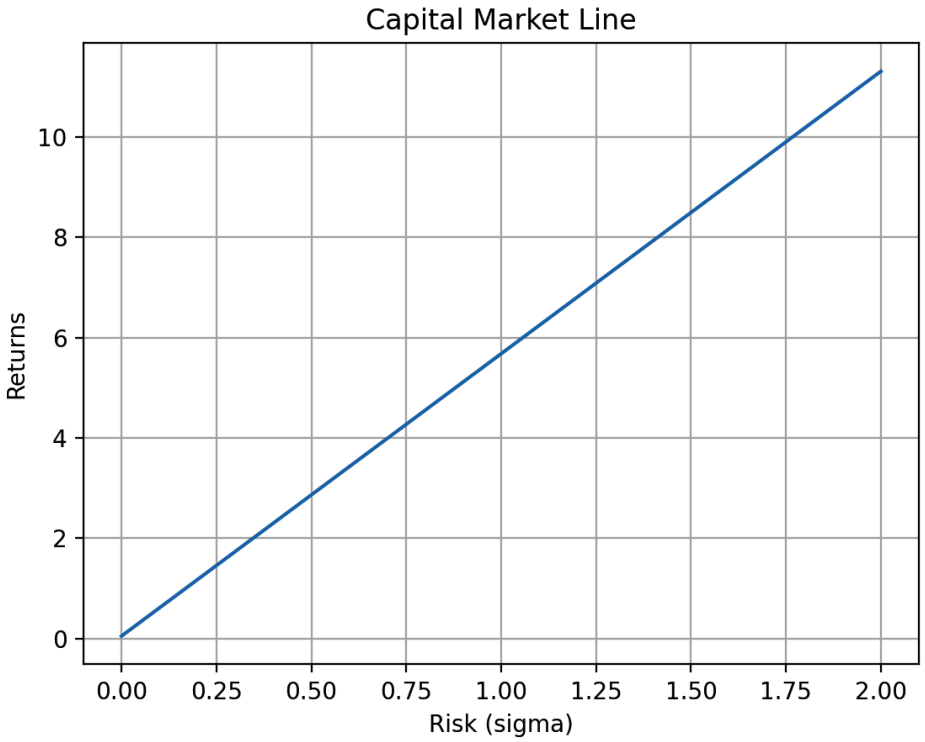

Capital Market Line with Markowitz Efficient Frontier
Minimum Variance Curve
Capital Market Line (CML)
Returns
Risk (sigma)
12
10
8
6
4
2
0
−2
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00


Capital Market Line
Returns
Risk (sigma)
10
8
6
4
2
0
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00

```
==================  sub-part (d) ==================

Eqn of Security Market Line is:
mu = 0.34 beta + 0.05
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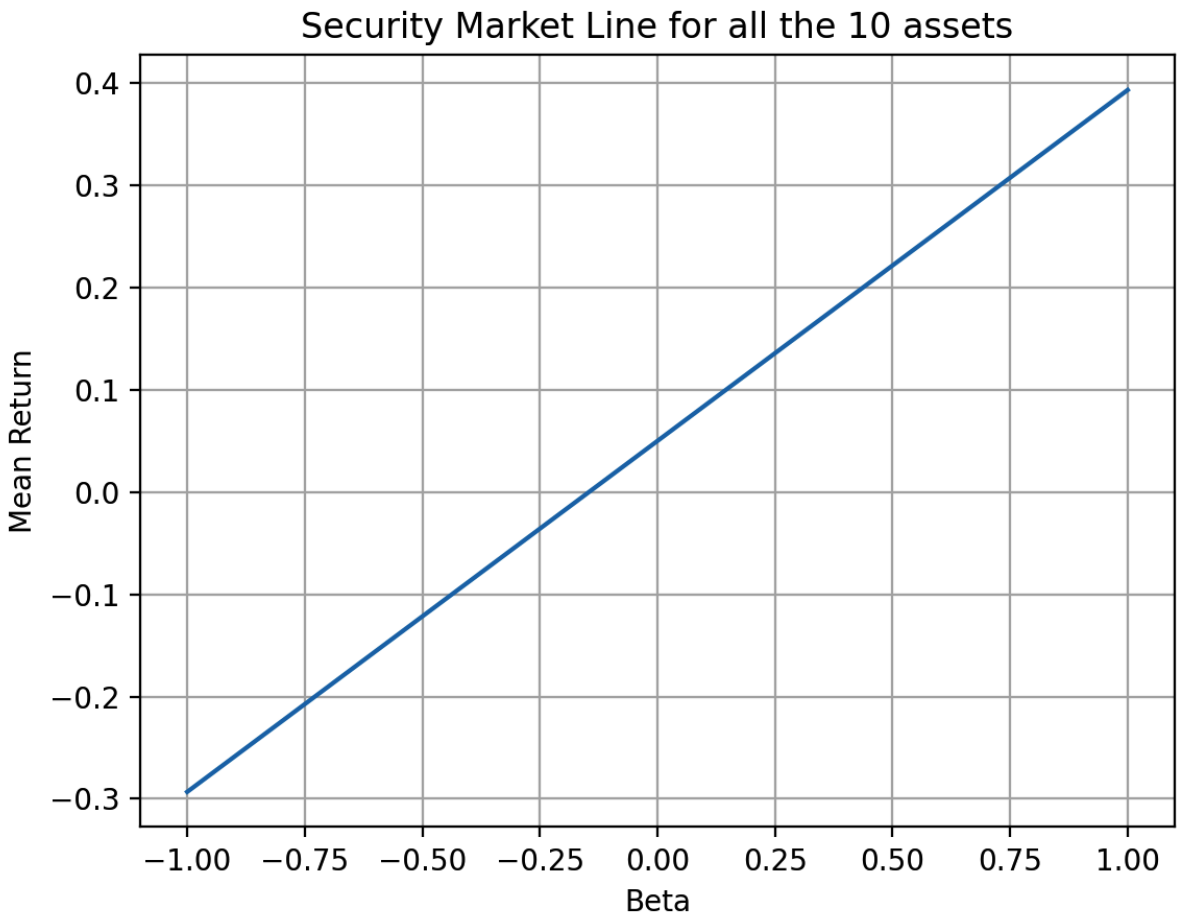

The Security market line is obtained using the following formula:

$$\mu = (\mu_M - \mu_{rf})\beta + \mu_{rf}$$

where,

μ_M = return corresponding to market portfolio

μ_{rf} = risk free return