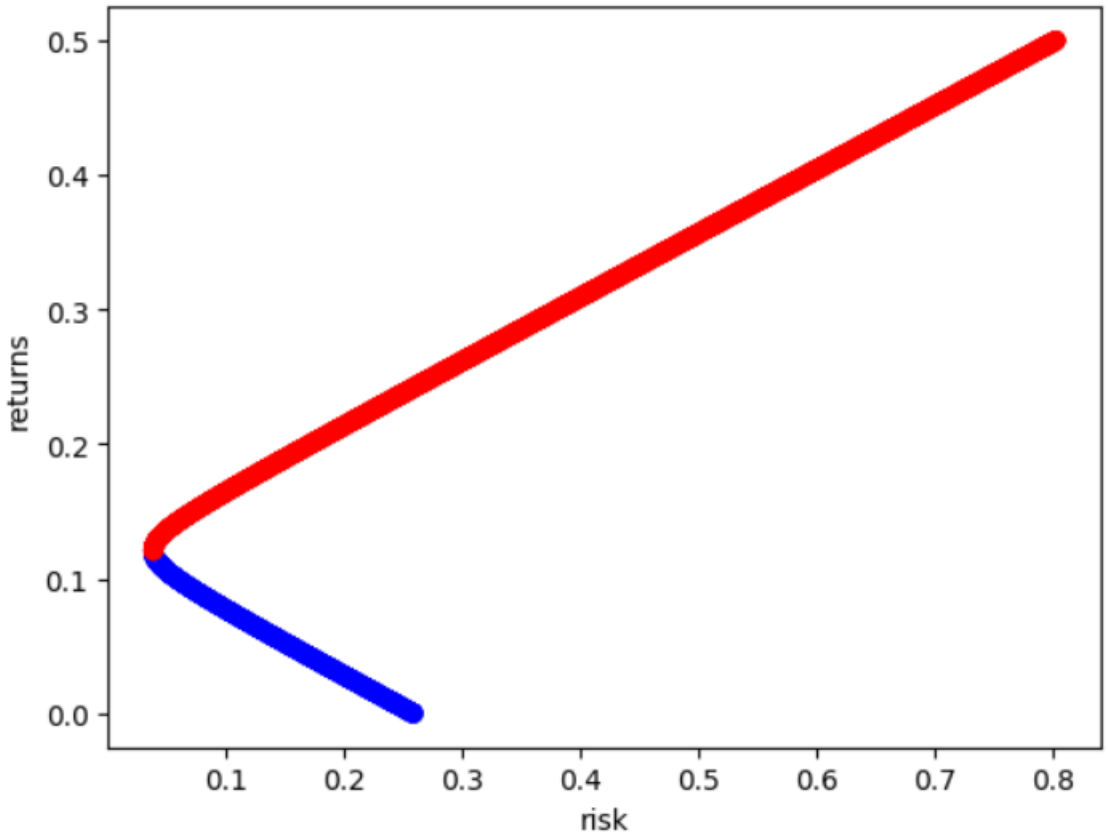
1)
a)



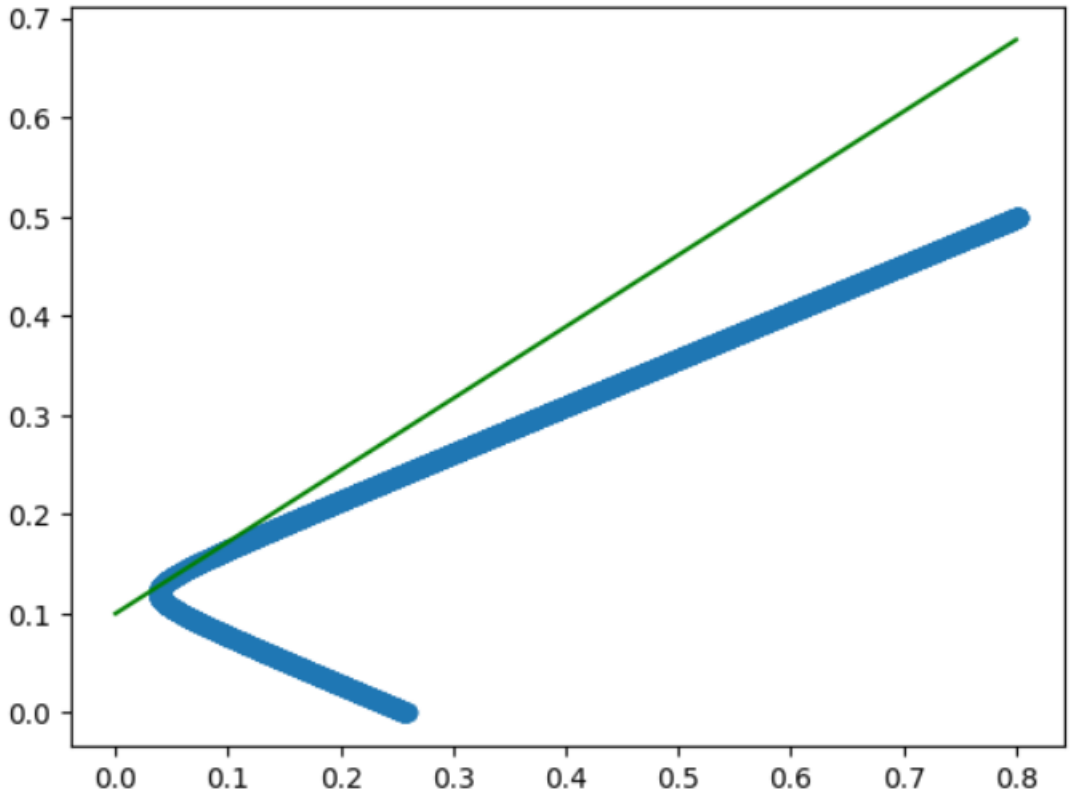
b)

index	returns	risk	weights
0	0	0.25879	[2.55045872 -0.44954128 -1.10091743]
1	0.0001	0.258581	[2.54902752 -0.44897248 -1.10005505]
2	0.0002	0.258372	[2.54759633 -0.44840367 -1.09919266]
3	0.0003	0.258163	[2.54616514 -0.44783486 -1.09833028]
4	0.0004	0.257954	[2.54473394 -0.44726606 -1.09746789]
5	0.0005	0.257745	[2.54330275 -0.44669725 -1.0966055]
6	0.0006	0.257536	[2.54187156 -0.44612844 -1.09574312]
7	0.0007	0.257326	[2.54044037 -0.44555963 -1.09488073]
8	0.0008	0.257117	[2.53900917 -0.44499083 -1.09401835]
9	0.0009	0.256908	[2.53757798 -0.44442202 -1.09315596]

c)two returns are possible:0.0524 and 0.1896
d)

```
[-0.02568807  0.57431193  0.45137615]
```

e)



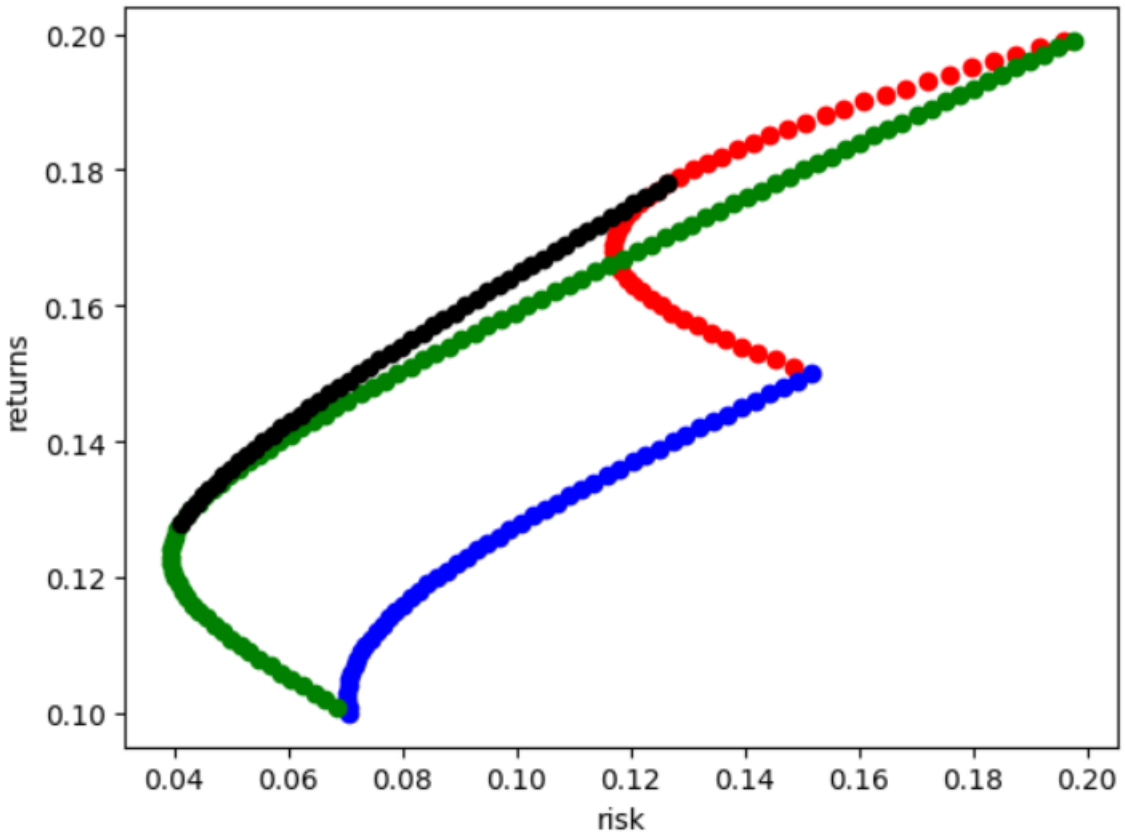
market portfolio:[0.0508,0.1367]

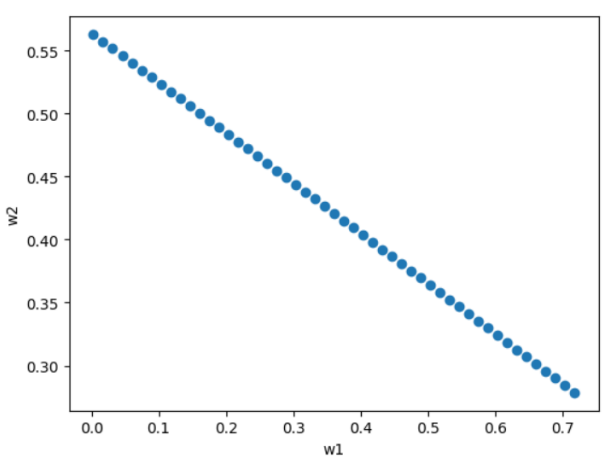
f)

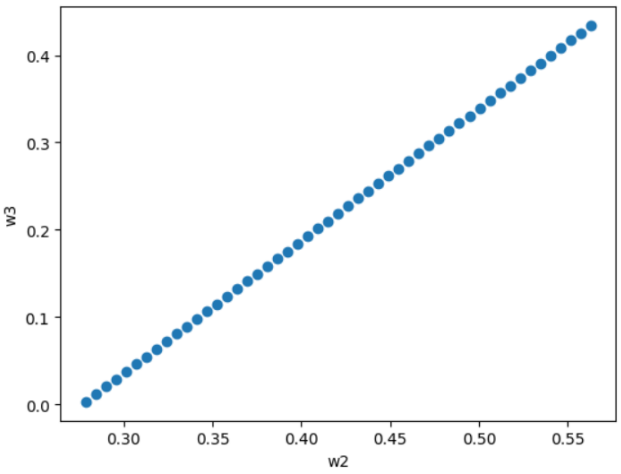
```
For 10%
 riskfree:(the first weight is that of riskfree)
   return[0.17226494] weights: [array([-0.96806658]), array([1.16853953, 0.64577185, 0.1537552 ])]
```

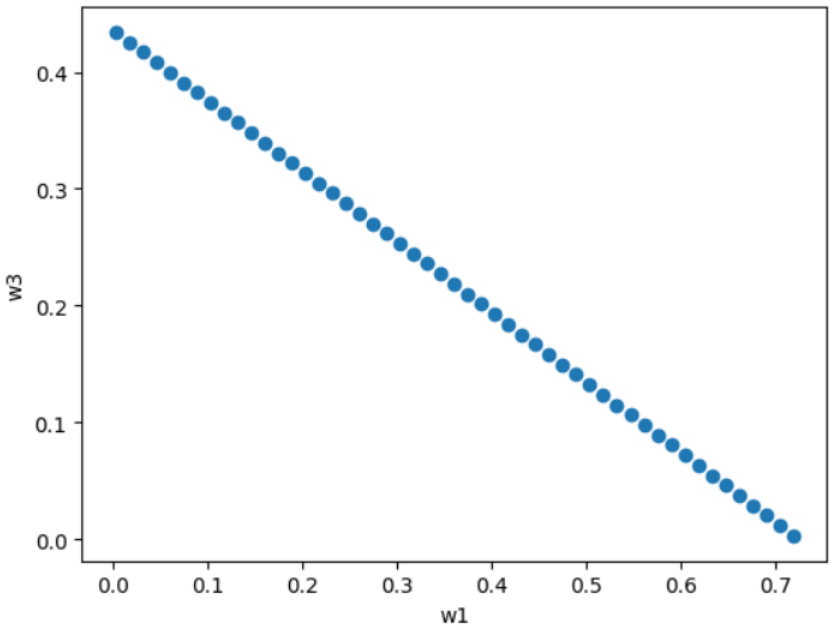
```
For 25%
 riskfree:(the first weight is that of riskfree)
   return[0.28066236] weights: [array([-3.92016644]), array([2.92134883, 1.61442961, 0.384388  ])]
```

2)


returns
risk
0.20
0.18
0.16
0.14
0.12
0.10
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20


w2
w1
0.55
0.50
0.45
0.40
0.35
0.30
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

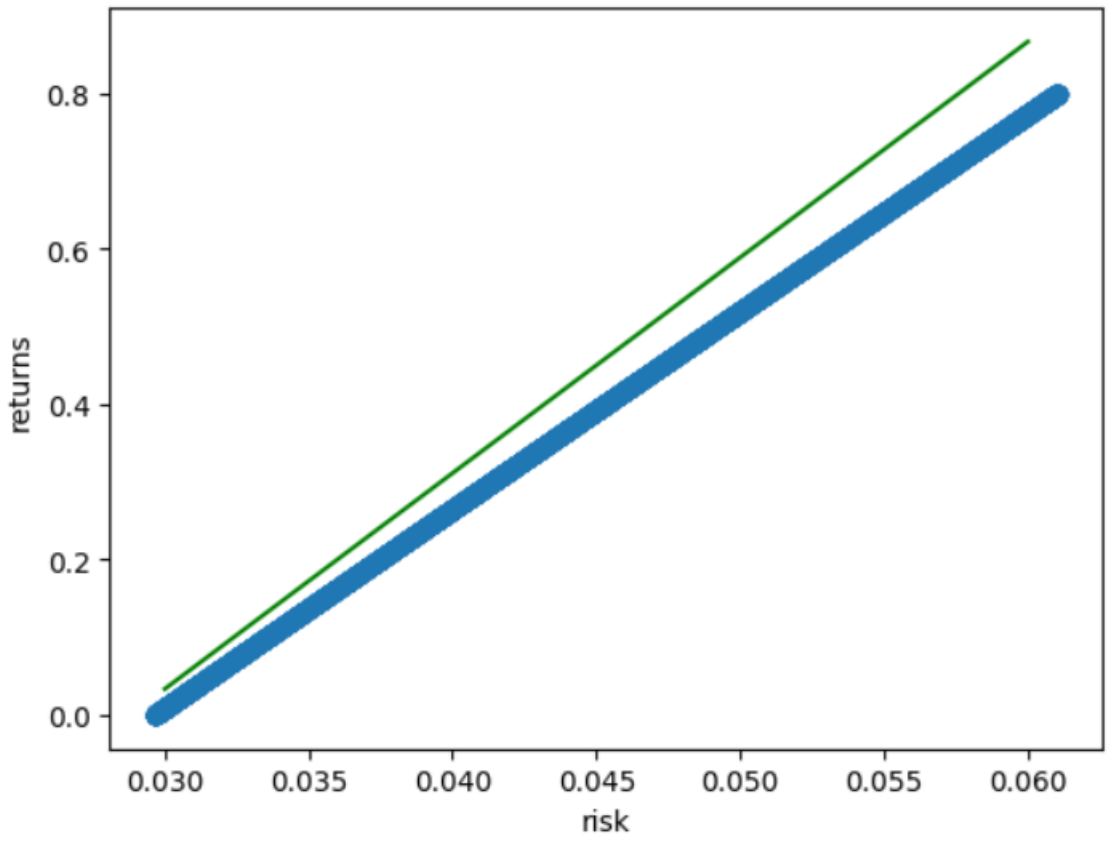

w3
w2
0.4
0.3
0.2
0.1
0.0
0.30
0.35
0.40
0.45
0.50
0.55


w3
w1
0.4
0.3
0.2
0.1
0.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

The equations are:
w2=-0.40*w1+0.56
w3=1.52*w2-0.42
w3=-0.60*w1+0.44

3)a)c)the green line is the CAPM line
the blue line is min variance portfolio curve(it almost seems like a line because the small covariance values of the data extracted)

I had to take risk free return rate(μ_{rf}) to be -0.8 in the whole duration.



b)

```
Market portfolio:
[[0.01324613],[-0.4320321]]
```

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

Here

$\mu_M = -0.432$

$\sigma_M = 0.0132$