```
In [3]:

#Question no 3
import math
import numpy as np
import matplotlib.pyplot as plt

u = [1,1,1,1,1,1,1,1,1,1]
v=np.transpose(u)
m = [0.4067,0.975,0.7804,-0.4696,0.2811,0.1796,0.06869,0.4289,0.0764,0.1094]
n=np.transpose(m)
c = [[36287.3174,4014.457,84026.129,137.9479,6266.541,1930.082,2343.791,3338.262
,618.222,3138.737],
     [4014.4575,550.675,12428.681,-428.197,808.234,257.617,277.858,408.038,78.85
4,308.338],
     [84026.129,12428.681,330344.305,-21151.436,19084.886,6151.104,5133.395,818
4.932,1677.820,3762.625],
     [137.947,-428.197,-21151.436,5159.857,-472.838,-307.813,354.504,12.551,0.69
83,826.690],
     [6266.541,808.234,19084.886,-472.838,1379.758,383.586,471.608,604.541,117.1
49,442.445],
     [1930.082,257.617,6151.104,-307.813,383.586,151.873,126.875,206.289,39.135,
133.422],
     [2343.791,277.858,5133.395,354.5049,471.608,126.875,290.328,260.016,48.510,
242.067],
     [338.262,408.038,8184.932,12.551,604.541,206.289,260.016,373.680,70.461,32
9.513],
     [618.222,78.854,1677.820,0.698,117.149,39.135,48.510,70.461,16.475,66.804],
     [3138.737,308.3385,3762.625,826.690,442.445,133.4228,242.0678,329.513,66.80
47,496.9038]]
k=np.linalg.inv(c)

return_1=[]
risk_1=[]


wmin= np.dot(u,k)
global_return=0
zeta=np.dot(np.dot(u,k),v)
for i in range(10):
  wmin[i]=wmin[i]/zeta
  global_return+=wmin[i]*m[i]

for i in range(101):
    return_1.append(i*0.004+global_return)
    r=[return_1[i],1]
    M=[[ np.dot(np.dot(m,k),n), np.dot(np.dot(u,k),n)], [np.dot(np.dot(m,k),v),
np.dot(np.dot(u,k),v)]]
    lam=np.dot(np.linalg.inv(M),r)
    a=lam[0]
    b=lam[1]
    q,y,w=[],[],[]
    for j in range(10):
      q.append(m[j]*a)
      y.append(u[j]*b)
    w_1=np.dot(q,k)
    w_2=np.dot(y,k)
    for j in range(10):
      w.append(w_1[j]+w_2[j])
    d=np.transpose(w)
```

```python
        var=np.dot(np.dot(w,c),d)
        sigma=math.sqrt(var)
        risk_1.append(sigma)

print("Efficient frontier")
print(" ")
plt.plot(risk_1,return_1,'r')
plt.xlabel('Portfolio Risk ')
plt.ylabel('Portfolio Return ')
plt.show()

risk_free=0.05
imp=[]
for i in range(10):
    imp.append(m[i]-risk_free)
mpw_phase1=np.dot(np.dot(imp,k),v)
market_portfolio=np.dot(imp,k)
for i in range(10):
    market_portfolio[i]=market_portfolio[i]/mpw_phase1
ret_market=0
for i in range(10):
    ret_market+=m[i]*market_portfolio[i]

msig=math.sqrt(np.dot(np.dot(market_portfolio,c),np.transpose(market_portfolio
)))

print(" ")
print("The market portfolio has return =",ret_market*100,'%')
print("and weights")
for s in range(10):
    print('w',s,' =',market_portfolio[s])
print("and risk =", math.sqrt(np.dot(np.dot(market_portfolio,c),np.transpose(mar
ket_portfolio)))*100,'%')
f,s=[],[]
print(" ")
print(" ")
for i in range(1000):
    f.append(0.003*i)
    s.append(risk_free+((ret_market-risk_free)*f[i])/msig)
kj=(ret_market-risk_free)/msig

print("The slope & intercept of the Cml are ",kj,'and',risk_free)
print(" ")
print("Capital Market line  to Efficient Frontier")
print(" ")
plt.plot(risk_1,return_1,'r',label='Efficient Frontier')
plt.plot(f,s,'b',label='Capital market line')
plt.xlabel('Portfolio Risk')
plt.ylabel('Portfolio Return ')
plt.legend(loc='lower right')
plt.show()

print('  ')
print('The slope & intercept of the security market line:', ret_market-risk_free
,'and',risk_free)
print(' ')
alicia,keys=[],[]
for i in range(100):
    alicia.append(i*0.06)
    keys.append((ret_market-risk_free)*alicia[i]+risk_free)
print("Security Market Line")
```
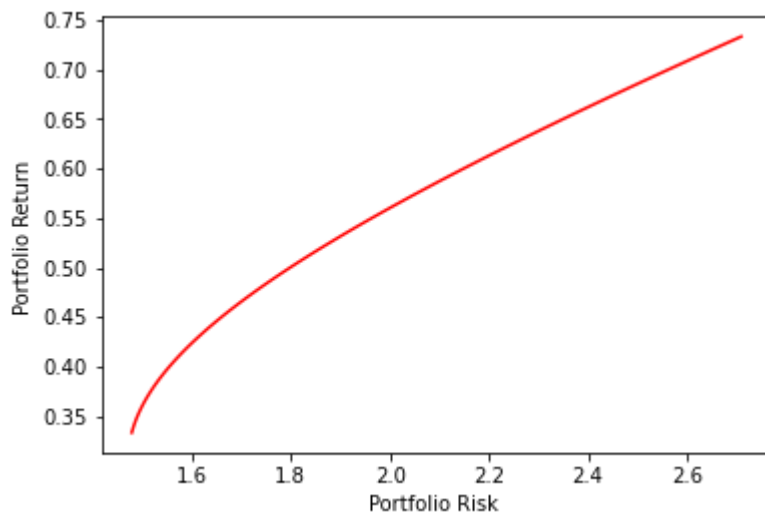
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print(' ')
plt.plot(alicia,keys,'r')
plt.xlabel('Beta')
plt.ylabel('Return')
plt.show()
```

Efficient frontier

The market portfolio has return = 67.20457252064791 %
and weights
w 0 = -0.021455871505141888
w 1 = 0.6994482255058907
w 2 = -0.02050789334284944
w 3 = 0.05840371897304199
w 4 = 0.08172560651817252
w 5 = 0.18560058390379544
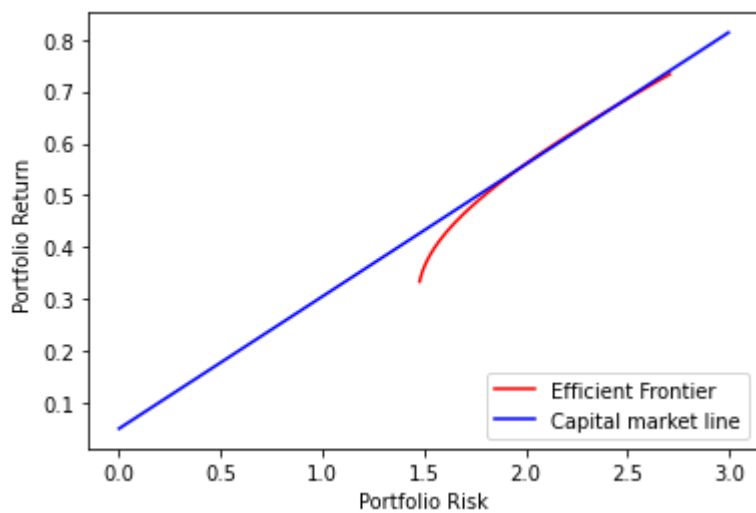w 6 = -0.23913094884208294
w 7 = -0.019640014767347513
w 8 = 0.5867503731184402
w 9 = -0.3111937795619192
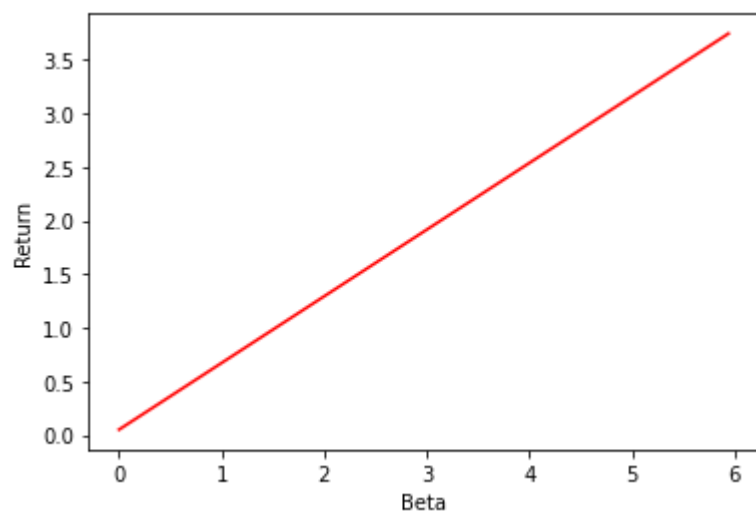and risk = 244.15142082427775 %

The slope & intercept of the Cml are 0.2547786628094955 and 0.05

Capital Market line to Efficient Frontier

The slope & intercept of the security market line: 0.622045725206479
and 0.05

Security Market Line

In [ ]: