Question 1. Using the shooting method, find the range of shooting angle of a canon to hit the target of diameter d=1, located at distance L=100. Set g=10 and fire speed v0=40

In [1]:

```
import numpy as np
import matplotlib.pyplot as plt
import scipy.integrate as integ
```

In [2]:

```
#time mesh
h=0.005
t=np.arange(0,8.0,h)

v0 = 40 #initicial velocity
g = 10 #gravitational acceleration

#distance we want
L = 100
d = 1
```

Set the function

In [3]:

```
def f(i_con,t):
    x,y,vx,vy = i_con #x_displacement, y_displacement, x_Velocity, y_velocity
    return [vx,vy,0,-g]
```

example

In [49]:

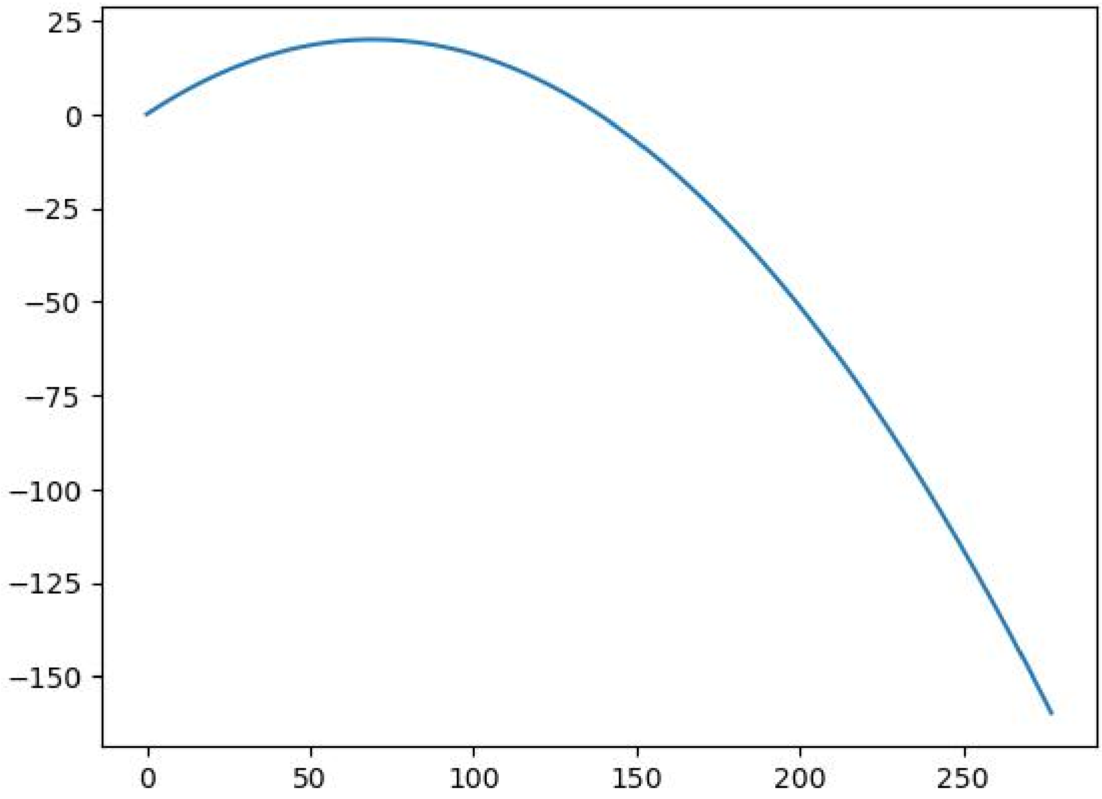
```
d_x = 0
theta = np.pi/6
r_theta = []
```

In [50]:

```
i_con = [0,0, v0*np.cos(theta), v0*np.sin(theta)]
sol = integ.odeint(f,i_con,t)
```

In [51]:

```
plt.plot(sol[:,0],sol[:,1]); plt.show()
```



In [54]:

```
for i in range(1,len(sol[:,1])):
    if sol[i,1] <= 0:
        break

print(sol[i,0])
```

138.5640646055102

In [45]:

```
sol[-1,1] # y_displacement for end
```

Out[45]:

-159.70012500000362

Find the range of shooting angle

In [38]:

```
d_x = 0
theta = 0 #unit : degree
r_theta = []
```

In [40]:

```
while d_x <= L + d/2 :

    i_con = [0,0, v0*np.cos(theta*np.pi/180), v0*np.sin(theta*np.pi/180)] #degree ->radian
    sol = integ.odeint(f,i_con,t)

    # for measuring x-distance, take time to y-displacement < 0
    for i in range(1,len(sol[:,0])) :
        if sol[i,1] <= 0 :
            break

    # take x-distance
    if sol[i,1] == 0 :
        d_x = sol[i,0]
    else :
        d_x = (sol[i-1,0]+ sol[i,0])/2

    # if x  - distnace comes to our range we want, then get it.
    if d_x > L-d/2 :
        r_theta.append(theta)

    print(theta,d_x)
    theta += 0.1
```

```
0 0.1
0.1 0.49999923845664374
0.2 1.0999932984235692
0.30000000000000004 1.6999766968206247
0.4 2.299943950622408
0.5 2.699897192273263
0.6 3.2998190589061904
0.7 3.8997089416757618
0.7999999999999999 4.499561358041869
0.8999999999999999 5.099370825656468
0.9999999999999999 5.499162323360152
1.0999999999999999 6.098875843942029
1.2 6.698530579281466
1.3 7.298121048055696
1.4000000000000001 7.897641769271351
1.5000000000000002 8.297155797297128
1.6000000000000003 8.896530023859151
1.7000000000000004 9.495818671134149
1.8000000000000005 10.09501625969389
1.9000000000000006 10.694117310576802
```

In [41]:

```
r_theta
```

Out[41]:

```
[19.300000000000004, 19.400000000000006, 19.500000000000007]
```