1. I used alpha=0,0001; 0,001 ; 0,01 and according to the plots, by increasing the value of alpha we decreased value of cost function.

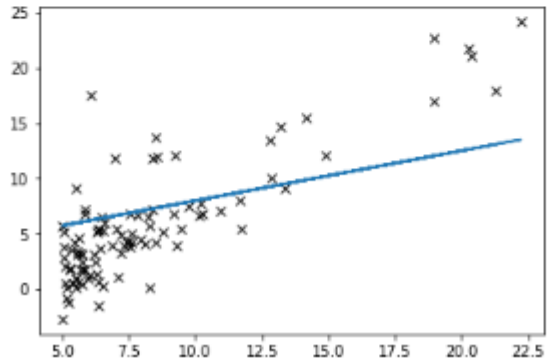
alpha=0.0001

In [49]:
```
tet0=5
tet1=10
a=0.0001
n=5000
m=97
for i in range(n):
    dtet0=[]
    dtet1=[]
    for j in range (len(X)):
        ms=tet0+tet1*X[j]-Y[j]
        ms1=(tet0+tet1*X[j]-Y[j])*X[j]
        dtet0.append(ms)
        dtet1.append(ms1)

    temp0=tet0-a/m*sum(dtet0)
    temp1=tet1-a/m*sum(dtet1)
    tet0=temp0
    tet1=temp1
print(tet0,tet1)
```

```
3.3516452802276318 0.46495107504826705
```

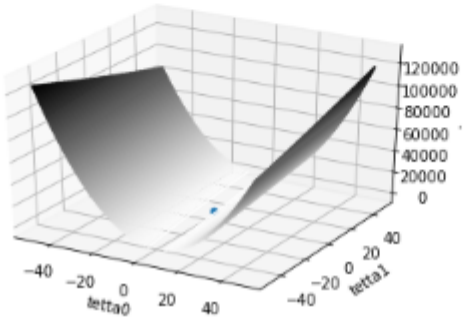
In [46]:
```
import matplotlib.pyplot as plt
import csv
import numpy as np
path='C:\\Users\shaly\Desktop\dataset.txt'

X = []
Y = []
H=[]

with open(path, 'r') as datafile:
    plotting = csv.reader(datafile, delimiter=',')
    for ROWS in plotting:
        X.append(float(ROWS[0]))
        Y.append(float(ROWS[1]))

for i in (X):
    h=tet0+tet1*i
    H.append(h)

plt.plot(X, Y, 'x',color='black')
plt.plot(X, H)
```

Out[46]:
```
[<matplotlib.lines.Line2D at 0x20d38b4da60>]
```



In [48]:
```
tt0=np.linspace(-50,50,100)
tt1=np.linspace(-50,50,100)
m=97
Js=np.zeros((100,100))
for j in range(len(tt0)):
    for k in range (len(tt1)):
        J=[]
        for i in range (len(X)):
            ms=(tt0[j]+tt1[k]*X[i]-Y[i])**2
            J.append(ms)
        s=1/(2*m)*sum(J)
        Js[j][k]=s

fig = plt.figure()
ax = plt.axes(projection='3d')
ax.contour3D(tt0,tt1,Js, 200, cmap='binary')
ax.set_xlabel('tetta0')
ax.set_ylabel('tetta1')
ax.set_zlabel('J');
ax.scatter3D(3.4834728590592037, 0.45170756484486096,9.434375774335823, cmap='Greens')
```

Out[48]:
```
<mpl_toolkits.mplot3d.art3d.Path3DCollection at 0x20d39cf0a60>
```



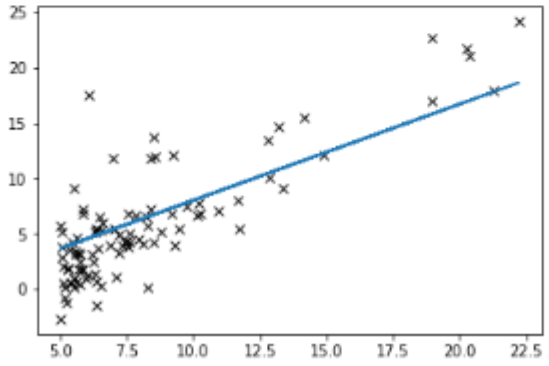
alpha=0.001

In [25]:
```
tet0=5
tet1=10
a=0.001
n=5000
m=97
for i in range(n):
    dtet0=[]
    dtet1=[]
    for j in range (len(X)):
        ms=tet0+tet1*X[j]-Y[j]
        ms1=(tet0+tet1*X[j]-Y[j])*X[j]
        dtet0.append(ms)
        dtet1.append(ms1)

    temp0=tet0-a/m*sum(dtet0)
    temp1=tet1-a/m*sum(dtet1)
    tet0=temp0
    tet1=temp1
print(tet0,tet1)
```

```
-0.6757278030404881 0.8695443854473608
```

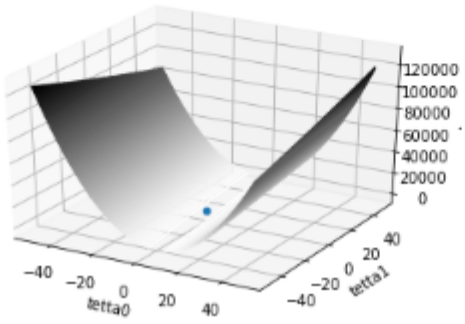
In [26]:
```
import matplotlib.pyplot as plt
import csv
import numpy as np
path='C:\\Users\shaly\Desktop\dataset.txt'

X = []
Y = []
H=[]

with open(path, 'r') as datafile:
    plotting = csv.reader(datafile, delimiter=',')
    for ROWS in plotting:
        X.append(float(ROWS[0]))
        Y.append(float(ROWS[1]))

for i in (X):
    h=tet0+tet1*i
    H.append(h)

plt.plot(X, Y, 'x',color='black')
plt.plot(X, H)
```

Out[26]:
```
[<matplotlib.lines.Line2D at 0x20d382fffd0>]
```



In [28]:
```
tt0=np.linspace(-50,50,100)
tt1=np.linspace(-50,50,100)
m=97
Js=np.zeros((100,100))
for j in range(len(tt0)):
    for k in range (len(tt1)):
        J=[]
        for i in range (len(X)):
            ms=(tt0[j]+tt1[k]*X[i]-Y[i])**2
            J.append(ms)
        s=1/(2*m)*sum(J)
        Js[j][k]=s

fig = plt.figure()
ax = plt.axes(projection='3d')
ax.contour3D(tt0,tt1,Js, 200, cmap='binary')
ax.set_xlabel('tetta0')
ax.set_ylabel('tetta1')
ax.set_zlabel('J');
ax.scatter3D(-0.6757278030404881, 0.8695443854473608,5.420935567772546, cmap='Greens')
```

Out[28]: <mpl_toolkits.mplot3d.art3d.Path3DCollection at 0x20d384ce220>



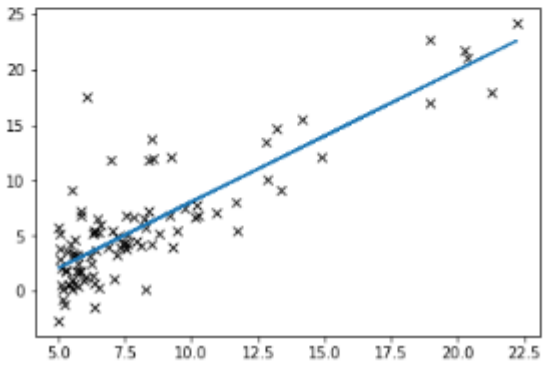
Alpha=0.01

In [29]:
```
tet0=5
tet1=10
a=0.01
n=5000
m=97
for i in range(n):
    dtet0=[]
    dtet1=[]
    for j in range (len(X)):
        ms=tet0+tet1*X[j]-Y[j]
        ms1=(tet0+tet1*X[j]-Y[j])*X[j]
        dtet0.append(ms)
        dtet1.append(ms1)

    temp0=tet0-a/m*sum(dtet0)
    temp1=tet1-a/m*sum(dtet1)
    tet0=temp0
    tet1=temp1
print(tet0,tet1)
```

```
-3.894822564500594 1.1929373711725966
```

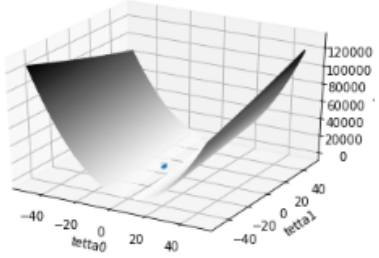
In [30]:
```
import matplotlib.pyplot as plt
import csv
import numpy as np
path='C:\\Users\shaly\Desktop\dataset.txt'

X = []
Y = []
H=[]

with open(path, 'r') as datafile:
    plotting = csv.reader(datafile, delimiter=',')
    for ROWS in plotting:
        X.append(float(ROWS[0]))
        Y.append(float(ROWS[1]))

for i in (X):
    h=tet0+tet1*i
    H.append(h)

plt.plot(X, Y, 'x',color='black')
plt.plot(X, H)
```

Out[30]: [<matplotlib.lines.Line2D at 0x20d38701df0>]



In [32]:
```
tt0=np.linspace(-50,50,100)
tt1=np.linspace(-50,50,100)
m=97
Js=np.zeros((100,100))
for j in range(len(tt0)):
    for k in range (len(tt1)):
        J=[]
        for i in range (len(X)):
            ms=(tt0[j]+tt1[k]*X[i]-Y[i])**2
            J.append(ms)
        s=1/(2*m)*sum(J)
        Js[j][k]=s

fig = plt.figure()
ax = plt.axes(projection='3d')
ax.contour3D(tt0,tt1,Js, 200, cmap='binary')
ax.set_xlabel('tetta0')
ax.set_ylabel('tetta1')
ax.set_zlabel('J');
ax.scatter3D(-3.894822564500594, 1.1929373711725966,4.476971459582625, cmap='Greens')
```

Out[32]: <mpl_toolkits.mplot3d.art3d.Path3DCollection at 0x20d37f66730>



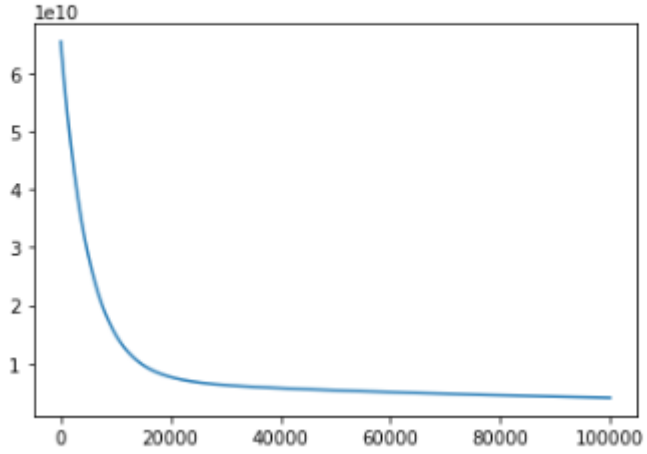
2.

In [98]:
```
#Gradient descent with mean normalization
import matplotlib.pyplot as plt
import csv
import numpy as np
path='C:\\Users\shaly\Desktop\dataset2.txt'
tet0=1
tet1=2
tet2=5
a=0.0001
n=100000
m=47
X = []
Y = []
Z = []
sj=[]
cnt=0

with open(path, 'r') as datafile:
    plotting = csv.reader(datafile, delimiter=',')
    for ROWS in plotting:
        X.append(float(ROWS[0]))
        Y.append(float(ROWS[1]))
        Z.append(float(ROWS[2]))

average_x=sum(X)/len(X)
average_y=sum(Y)/len(Y)
s1=max(X)-min(X)
s2=max(Y)-min(Y)


while cnt!=n:
    cnt=cnt+1
    dtet0=[]
```

```
while cnt!=n:
    cnt=cnt+1
    dtet0=[]
    dtet1=[]
    dtet2=[]
    for j in range (len(X)):
        ms=(tet0+tet1*((X[j]-average_x)/s1)+tet2*((Y[j]-average_y)/s2)-Z[j])*1
        ms1=(tet0+tet1*((X[j]-average_x)/s1)+tet2*((Y[j]-average_y)/s2)-Z[j])*(X[j]-average_x)/s1
        ms2=(tet0+tet1*((X[j]-average_x)/s1)+tet2*((Y[j]-average_y)/s2)-Z[j])*(Y[j]-average_y)/s2
        dtet0.append(ms)
        dtet1.append(ms1)
        dtet2.append(ms2)

    temp0=tet0-a/m*sum(dtet0)
    temp1=tet1-a/m*sum(dtet1)
    temp2=tet2-a/m*sum(dtet2)
    tet0=temp0
    tet1=temp1
    tet2=temp2

    J=[]
    for k in range (len(X)):
        mj=(tet0+tet1*((X[k]-average_x)/s1)+tet2*((Y[k]-average_y)/s2)-Z[k])**2
        J.append(mj)
    s=1/(2*m)*sum(J)
    sj.append(s)

print(tet0,tet1,tet2)
plt.plot(np.linspace(0,n-1,n),sj)
```

```
340397.212634948 175391.30152182438 67291.00961468875
```

Out[98]: [<matplotlib.lines.Line2D at 0x1538327d040>]



3.

In [64]:
```
#Normal equation
import matplotlib.pyplot as plt
import csv
import numpy as np
import math
n=2
m=47
X=np.zeros((m,n+1))
path='C:\\Users\shaly\Desktop\dataset2.txt'
x1=[]
x2=[]
y=[]
with open(path, 'r') as datafile:
    plotting = csv.reader(datafile, delimiter=',')
    for ROWS in plotting:
        x1.append(float(ROWS[0]))
        x2.append(float(ROWS[1]))
        y.append(float(ROWS[2]))
for i in range(m):
    X[i][0]=1
    X[i][1]=x1[i]
    X[i][2]=x2[i]
X_tr=np.transpose(X)
x_transpose_dot_x = X_tr.dot(X)
temp_1 = np.linalg.inv(x_transpose_dot_x)
temp_2 = X_tr.dot(y)
theta= temp_1.dot(temp_2)
print(theta)
```

```
[89597.9095428    139.21067402 -8738.01911233]
```