Linear Regression

import library

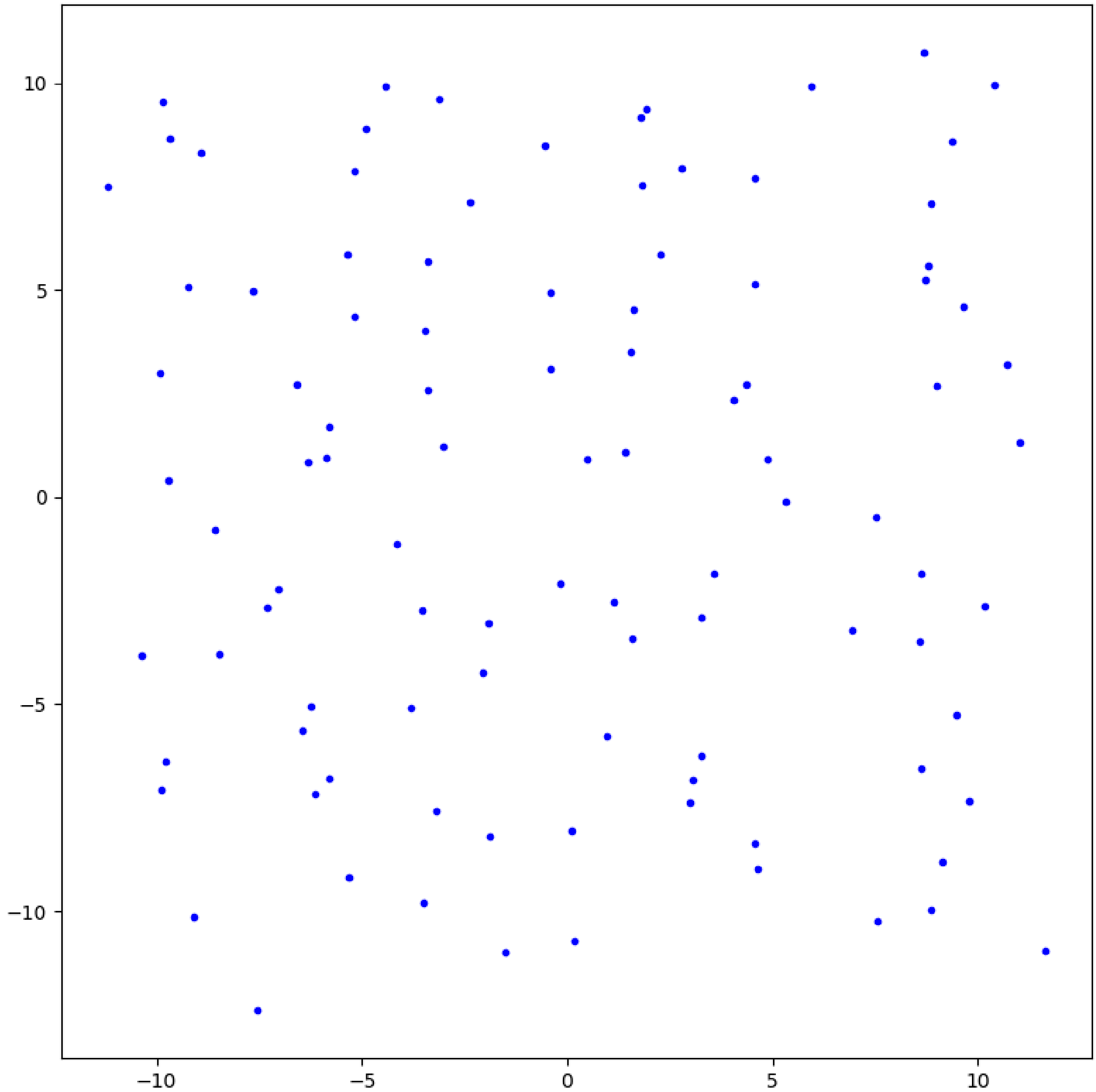
In [ ]:
```
%matplotlib inline
import numpy as np
import matplotlib.image as img
import matplotlib.pyplot as plt
import matplotlib.colors as colors
from mpl_toolkits.mplot3d import Axes3D
import util
```

load point data for training $(x, y, z) \in \mathbb{R}^3$

In [ ]:
```
fname_data  = '07_data.csv'
data        = np.genfromtxt(fname_data, delimiter=',')
num_data    = data.shape[0]

x = np.zeros(num_data)
y = np.zeros(num_data)
z = np.zeros(num_data)

for i in range(num_data):
    x[i] = data[i,0]
    y[i] = data[i,1]
    z[i] = data[i,2]

x = np.reshape(x, (num_data, 1))
y = np.reshape(y, (num_data, 1))
z = np.reshape(z, (num_data, 1))
```

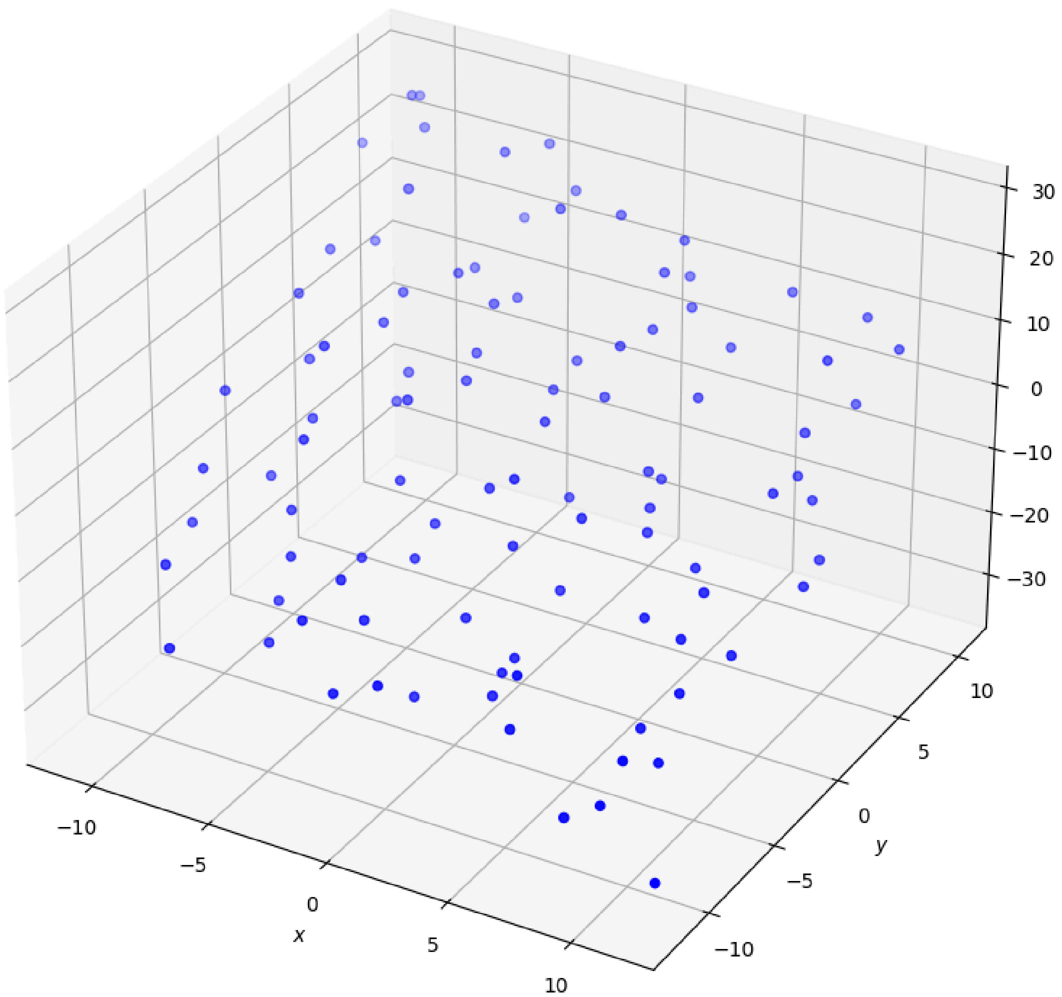
visualize the projection of the three dimensional points to the xy -plane

In [ ]:
```
plt.figure(figsize=(8,8))
plt.plot(x, y, '.', color = 'blue')
plt.tight_layout()
plt.show()
```



visualize the data points in the three dimensional space

In [ ]:
```
fig = plt.figure(figsize=(8, 8))
ax1 = plt.subplot(111, projection='3d')
ax1.set_xlabel('$x$')
ax1.set_ylabel('$y$')
ax1.set_zlabel('$z$')
ax1.scatter(x, y, z, marker='o', color='blue')
plt.tight_layout()
plt.show()
```



In [ ]:
```
print('num of x =', len(x))
print('num of y =', len(y))
print('num of z =', len(z))
```

```
num of x = 100
num of y = 100
num of z = 100
```

construct matrix A as given by:

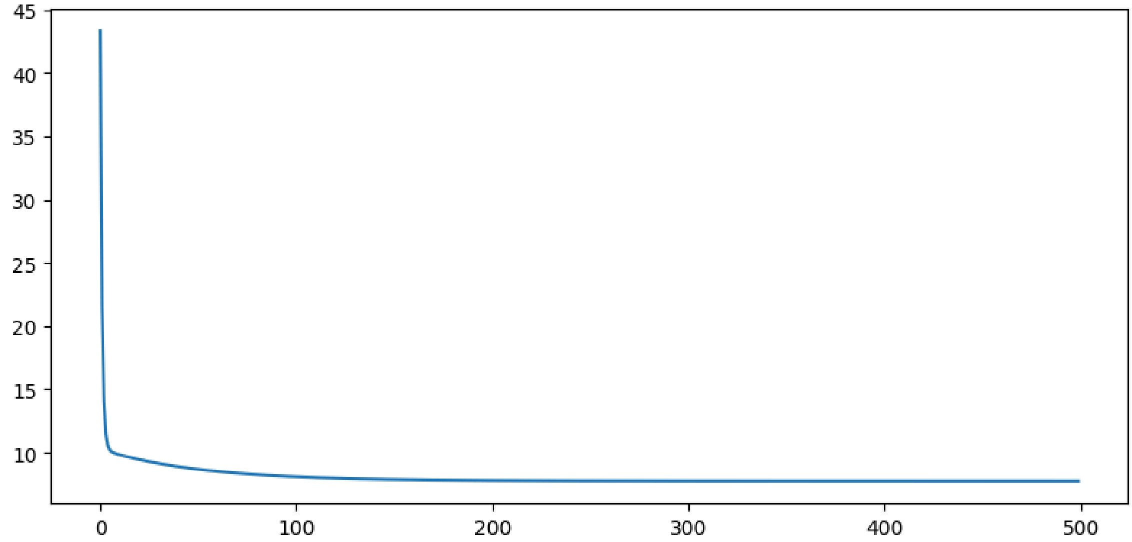
$$A = \begin{bmatrix} 1 & x_1 & y_1 \\ 1 & x_2 & y_2 \\ \vdots & \vdots & \vdots \\ 1 & x_n & y_n \end{bmatrix}, \quad \theta = \begin{bmatrix} \theta_0 \\ \theta_1 \\ \theta_2 \end{bmatrix}, \quad z = \begin{bmatrix} z_1 \\ z_2 \\ \vdots \\ z_n \end{bmatrix}$$

solve the linear regression problem by the gradient descent algorithm

In [ ]:
```
lr          = 0.01
num_iter    = 500
theta       = np.zeros((3, 1))
loss_iter   = []
theta0_iter = []
theta1_iter = []
theta2_iter = []

for i in range(num_iter):
    A        = util.get_matrix_A_linear_regression(x, y)
    grad     = util.compute_gradient(A, z, theta)
    theta    = theta - lr * grad
    loss     = util.compute_loss(A, z, theta)
    loss_iter.append(loss.item())
    theta0_iter.append(theta[0].item())
    theta1_iter.append(theta[1].item())
    theta2_iter.append(theta[2].item())
```

In [ ]:
```
def plot_01():
    plt.figure(figsize=(8,4))
    plt.plot(loss_iter)
    plt.tight_layout()
    plt.show()
    print('loss sum =', sum(loss_iter))
```

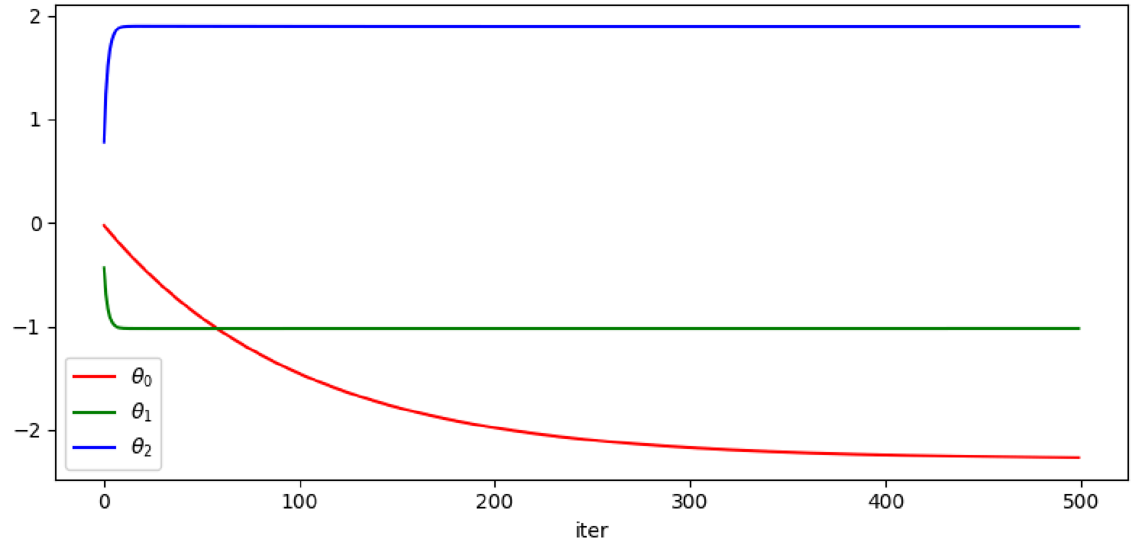
In [ ]:
```
plot_01()
```




```
loss sum = 4053.4995897447566
```

In [ ]:
```
def plot_02():
    plt.figure(figsize=(8,4))
    plt.plot(theta0_iter, '-', color='red', label=r'$\theta_0$')
    plt.plot(theta1_iter, '-', color='green', label=r'$\theta_1$')
    plt.plot(theta2_iter, '-', color='blue', label=r'$\theta_2$')
    plt.xlabel('iter')
    plt.legend()
    plt.tight_layout()
    plt.show()
    print('sum theta0 =', sum(theta0_iter))
    print('sum theta1 =', sum(theta1_iter))
    print('sum theta2 =', sum(theta2_iter))
```

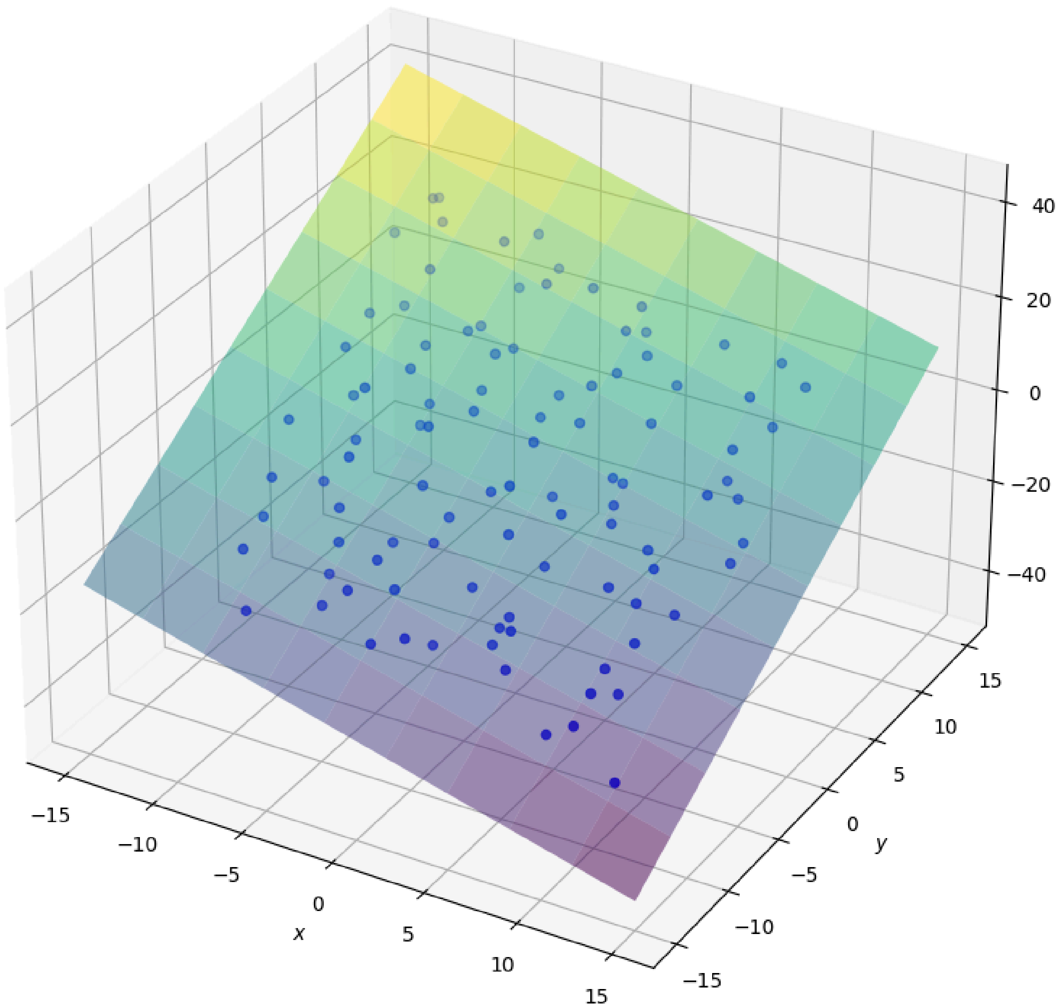
In [ ]:
```
plot_02()
```




```
sum theta0 = -916.4012597089699
sum theta1 = -508.5148336164769
sum theta2 = 945.6099519418051
```

In [ ]:
```
def plot_03():
    XX = np.linspace(-15, 15, 10)
    YY = np.linspace(-15, 15, 10)
    (grid_XX, grid_YY) = np.meshgrid(XX, YY)
    grid_ZZ = theta[0] + theta[1] * grid_XX + theta[2] * grid_YY

    fig = plt.figure(figsize=(8, 8))
    ax1 = plt.subplot(111, projection='3d')
    ax1.set_xlabel('$x$')
    ax1.set_ylabel('$y$')
    ax1.set_zlabel('$z$')
    ax1.plot_surface(grid_XX, grid_YY, grid_ZZ, rstride=1, cstride=
1, cmap='viridis', edgecolor='none', alpha=0.5)
    ax1.scatter(x, y, z, marker='o', color='blue')
    plt.tight_layout()
    plt.show()
    print('sum of z =', grid_ZZ.sum())
```

In [ ]:
```
plot_03()
```

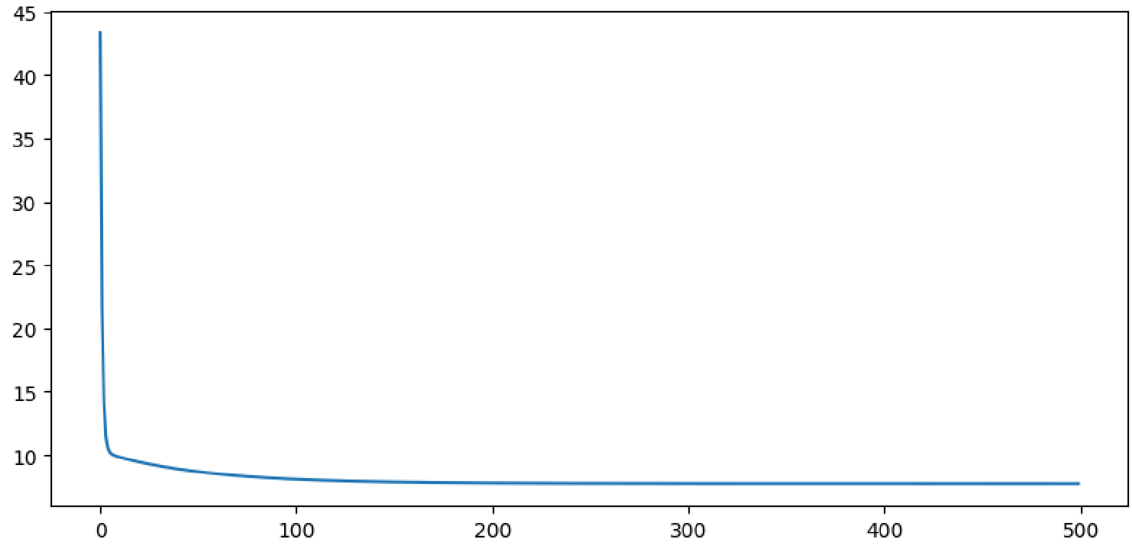



```
sum of z = -226.586484584474
```

results

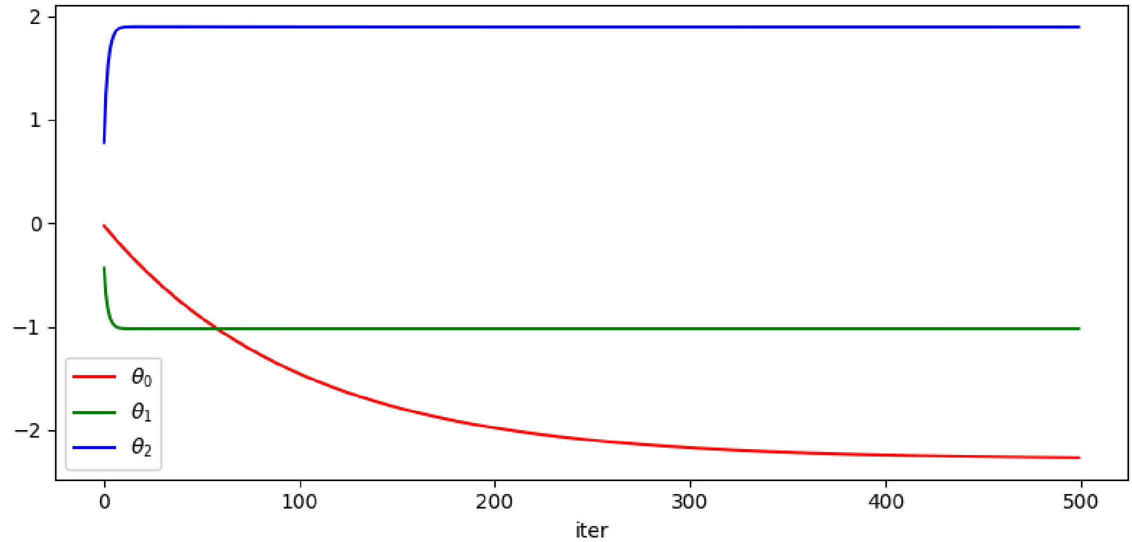
In [ ]:
```python
number_result = 3

for i in range(number_result):
    title           = '# RESULT # {:02d}'.format(i+1)
    name_function   = 'plot_{:02d}()'.format(i+1)

    print('')
    print('################################################################################')
    print(title)
    print('################################################################################')
    print('')

    eval(name_function)
```

```
##############################################################################
# RESULT # 01
##############################################################################
```



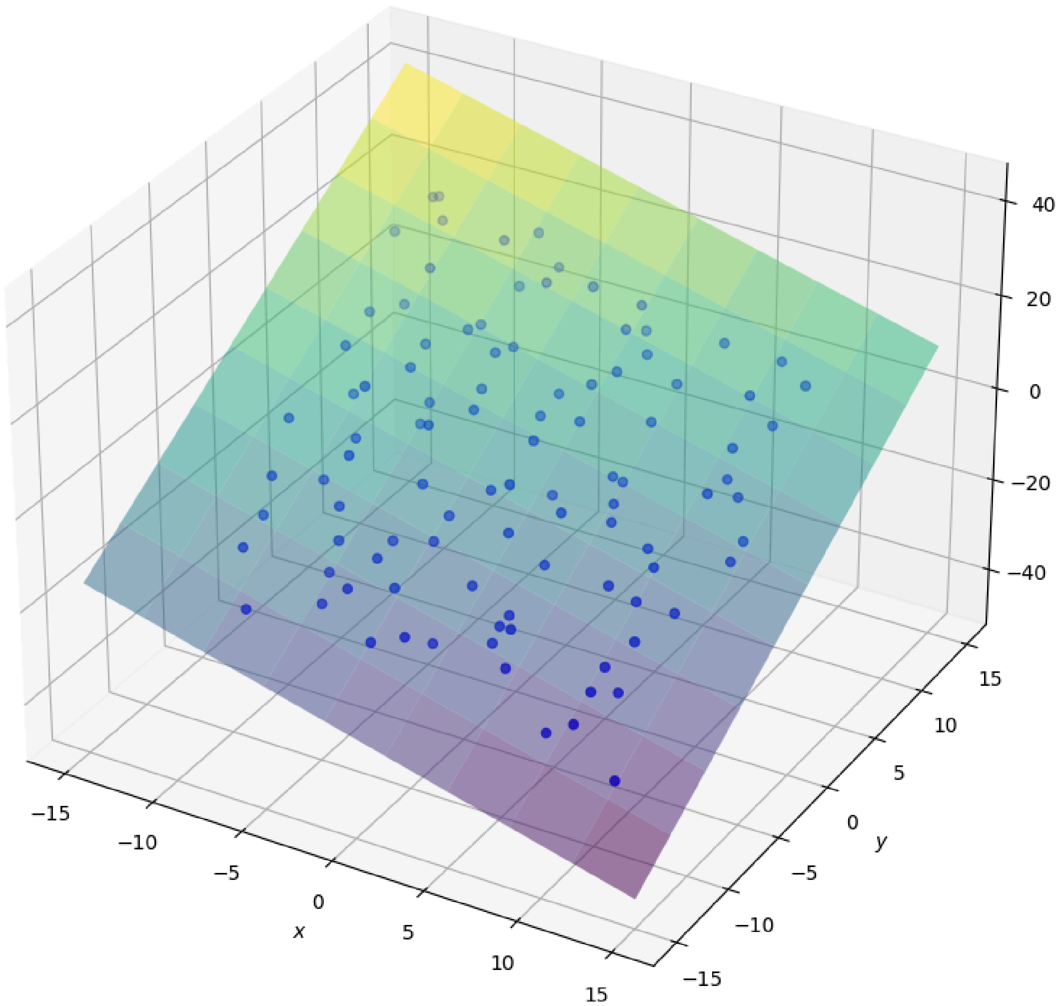

```
loss sum = 4053.4995897447566
```

```
##############################################################################
# RESULT # 02
##############################################################################
```




```
sum theta0 = -916.4012597089699
sum theta1 = -508.5148336164769
sum theta2 = 945.6099519418051
```

```
##############################################################################
# RESULT # 03
##############################################################################
```




```
sum of z = −226.586484584474
```

In [ ]: