Artificial Intelligence Lab Work (2)

レポート解答用紙（Report Answer Sheet）

学生証番号（Student ID): 20521150

名前(Name): Pham Quoc Cuong（ファン・ゴック・クオン）

```
#Data D
X = [0.349526784, 1.6974435, 5.384308891, 2.044150596,
     4.578814506, 3.241690807, 2.535931731, 2.210580888,
     3.397474351, 5.972933146, 5.114704101]

Y = [0.254020646, 0.790556868, -0.81239532, 1.012143475,
     -0.904558188, -0.167456361, 0.482547054, 0.878514378,
     -0.210093715, -0.128786937, -0.866501299]
```

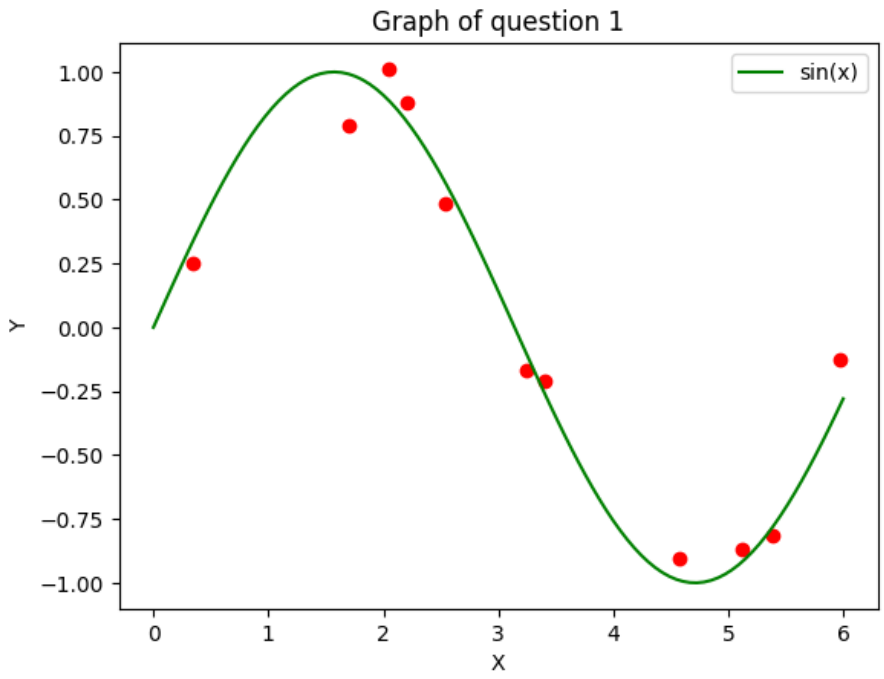
問 1.

（プログラム）

Q1. Write a program to draw the scatter plot of the data D and sin function for the range 0 ≤ x ≤ 6, and generate a graph.

```
[3]  x_sin = np.linspace(0, 6, 100)
     plt.scatter(X, Y, color='red')
     plt.plot(x_sin, np.sin(x_sin), color='green', label='sin(x)')
     plt.title("Graph of question 1")
     plt.xlabel("X")
     plt.ylabel("Y")
     plt.legend()
     plt.show()
```

（グラフ）



問 2.

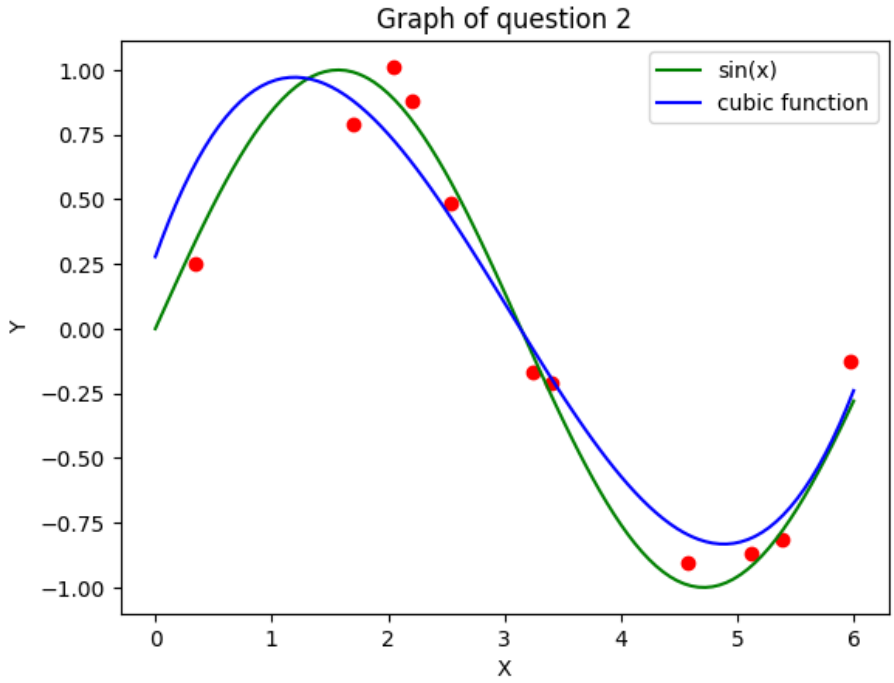
（プログラム）

Q2 Write a gradient descent method program to find the parameters a, b, c, and d of the cubic function $y = ax^3 + bx^2 + cx + d$ from the data D. Generate a scatter plot of the data D for the range 0 ≤ x ≤ 6 and a graph showing the sin function and the cubic function.

```
[4] def cubic(a, b, c , d, x):
      return a*x**3 + b*x**2 + c*x + d
```

```
[5] epoch = 200000
    lr = 0.000008

    a = 0
    b = 0
    c = 0
    d = 0

    for times in range(epoch):
      grad_a = 0
      grad_b = 0
      grad_c = 0
      grad_d = 0
      loss = 0

      for i in range(len(X)):
        x = X[i]
        y = Y[i]
        grad_a = grad_a - 2*x**3*(y - a*x**3 - b*x**2 - c*x - d)
        grad_b = grad_b - 2*x**2*(y - a*x**3 - b*x**2 - c*x - d)
        grad_c = grad_c - 2*x*(y - a*x**3 - b*x**2 - c*x - d)
        grad_d = grad_d - 2*(y - a*x**3 - b*x**2 - c*x - d)
        loss = loss + (y-a*x**3 - b*x**2 - c*x -d)**2
      a = a - lr * grad_a
      b = b - lr * grad_b
      c = c - lr * grad_c
      d = d - lr * grad_d

    print(a, b, c, d)

    x_sin = np.linspace(0,6,100)
    plt.scatter(X, Y, color='red')
    plt.plot(x_sin, np.sin(x_sin), color='green', label='sin(x)')
    plt.plot(x_sin, cubic(a, b, c, d, x_sin), color='blue', label='cubic function')
    plt.xlabel("X")
    plt.ylabel("Y")
    plt.legend()
    plt.title("Graph of question 2")
    plt.show()
```

（グラフ）


Graph of question 2
sin(x)
cubic function
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
Y
0
1
2
3
4
5
6
X

問 3. (a)

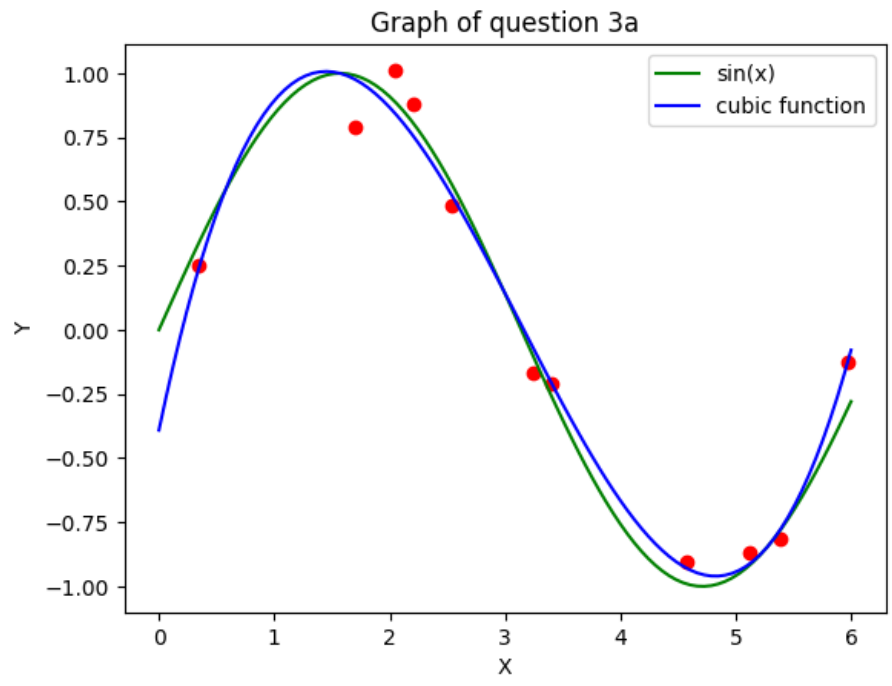
(プログラム)

Q3 Consider a learning method using the analytical solution of the least-squares method to find parameters for data D. Answer the following (a) and (b).

(a) Write a learning method program using the least-squares analytical solution to find the parameters w0, w1, w2, w3 of the cubic function $y = w0 + w1x + w2x^2 + w3x^3$ from the data D, and generate a graph drawing scatterplot of the data D, the sin function and cubic function for the range 0 ≤ x ≤ 6.

```
[6] X3 = []
    for x in X:
      X3 = X3 + [[1, x, x**2, x**3]]
    X3 = np.array(X3)
    Y3 = np.array([Y]).T

    Z1 = np.matmul(X3.T, X3)
    Z2 = np.linalg.inv(Z1)
    Z3 = np.matmul(Z2, X3.T)
    w = np.matmul(Z3, Y3)
    print(w)

    def cubic_func(x):
      return w[3][0]*x**3 + w[2][0]*x**2 + w[1][0]*x + w[0][0]

    x_sin = np.linspace(0,6,100)
    plt.scatter(X, Y, color='red')
    plt.plot(x_sin, np.sin(x_sin), color='green', label='sin(x)')
    plt.plot(x_sin, cubic_func(x_sin), color='blue', label='cubic function')
    plt.legend()
    plt.xlabel("X")
    plt.ylabel("Y")
    plt.title("Graph of question 3a")
    plt.show()
```

(グラフ)



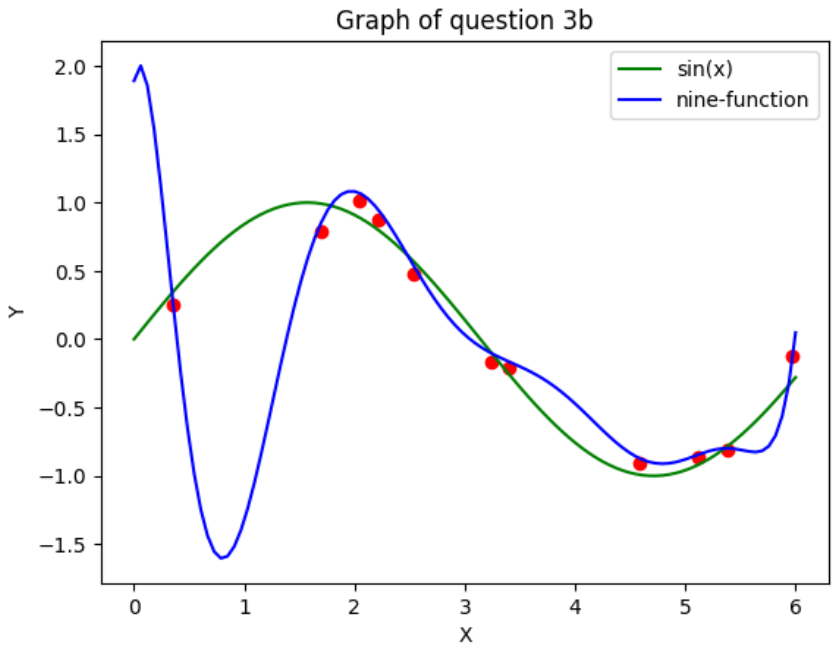
問 3. (b) 1st way

(プログラム)

(b) Write a learning method program using the least-squares analytical solution to find the parameters w0, w1, w2, w3, w4, w5, w6, w7, w8, w9 of the ninth-order function $y = w0 + w1x + w2x^2 + w3x^3 + w4x^4 + w5x^5 + w6x^6 + w7x^7 + w8x^8 + w9x^9$ from the data D, and generate a graph drawing scatterplot of the data D, the sin function and the ninth-order function for the range 0 ≤ x ≤ 6.

```
[7] X9 = []

    for x in X:
      t = []
      for i in range(10):
        t.append(x**i)
      X9 = X9 + [t]

    X9 = np.array(X9)
    Y9 = np.array([Y]).T

    Z1 = np.matmul(X9.T, X9)
    Z2 = np.linalg.inv(Z1)
    Z3 = np.matmul(Z2, X9.T)
    w = np.matmul(Z3, Y9)
    print(w)

    def nine_func(x):
      value = 0
      for i in range(10):
        value += w[i][0]*x**i
      return value

    x_sin = np.linspace(0,6,100)
    plt.scatter(X, Y, color='red')
    plt.plot(x_sin, np.sin(x_sin), color='green', label='sin(x)')
    plt.plot(x_sin, nine_func(x_sin), color='blue', label='nine-function')
    plt.legend()
    plt.xlabel("X")
    plt.ylabel("Y")
    plt.title("Graph of question 3b")
    plt.show()
```

(グラフ)



問 3. (b) 2nd way

(プログラム)

```
X_ = np.array(X)
Y_ = np.array(Y)
A = np.vstack([np.ones(len(X_)), \
               X_**1,  X_**2, X_**3, X_**4, X_**5, X_**6, X_**7, X_**8, X_**9,]).T
w = np.linalg.lstsq(A, Y_, rcond=None)[0]
x_range = np.linspace(0, 6, 100)
y_range = w[0] + w[1]*x_range + w[2]*x_range**2 + w[3]*x_range**3 + w[4]*x_range**4 \
            + w[5]*x_range**5 + w[6]*x_range**6 + w[7]*x_range**7 + w[8]*x_range**8 + w[9]*x_range**9

plt.scatter(X,Y, color="red")
plt.plot(x_range, np.sin(x_range), color="green", label='sin(x)')
plt.plot(x_range, y_range, color="blue", label='cubic function')
plt.title ("Graph 3b")
plt.legend()
plt.show()
```

(グラフ)