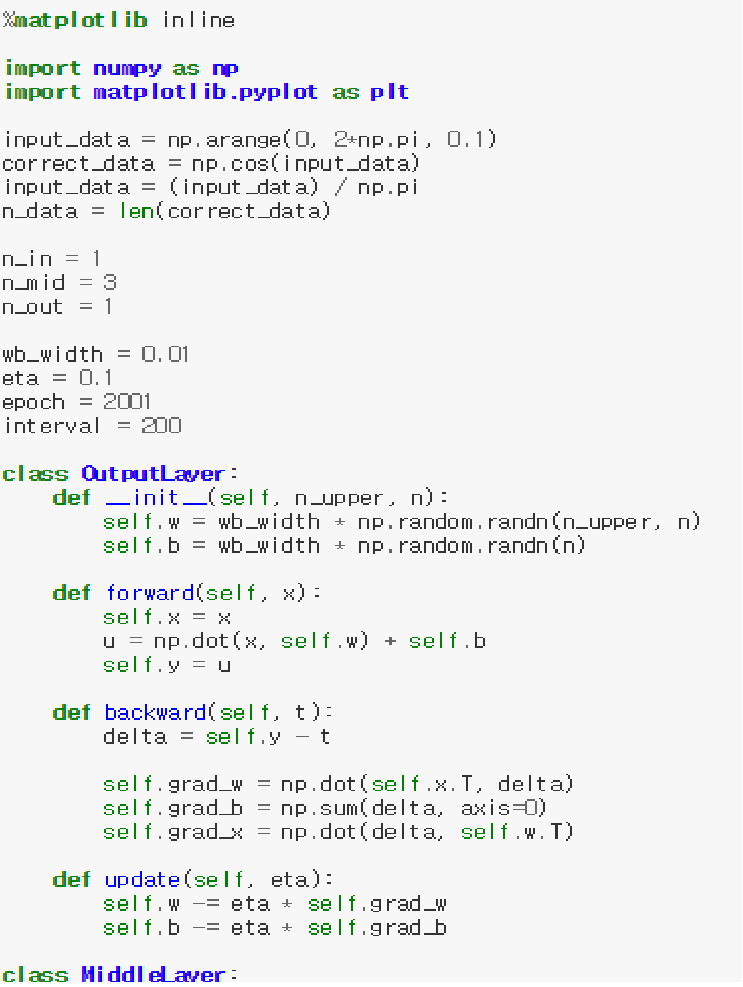
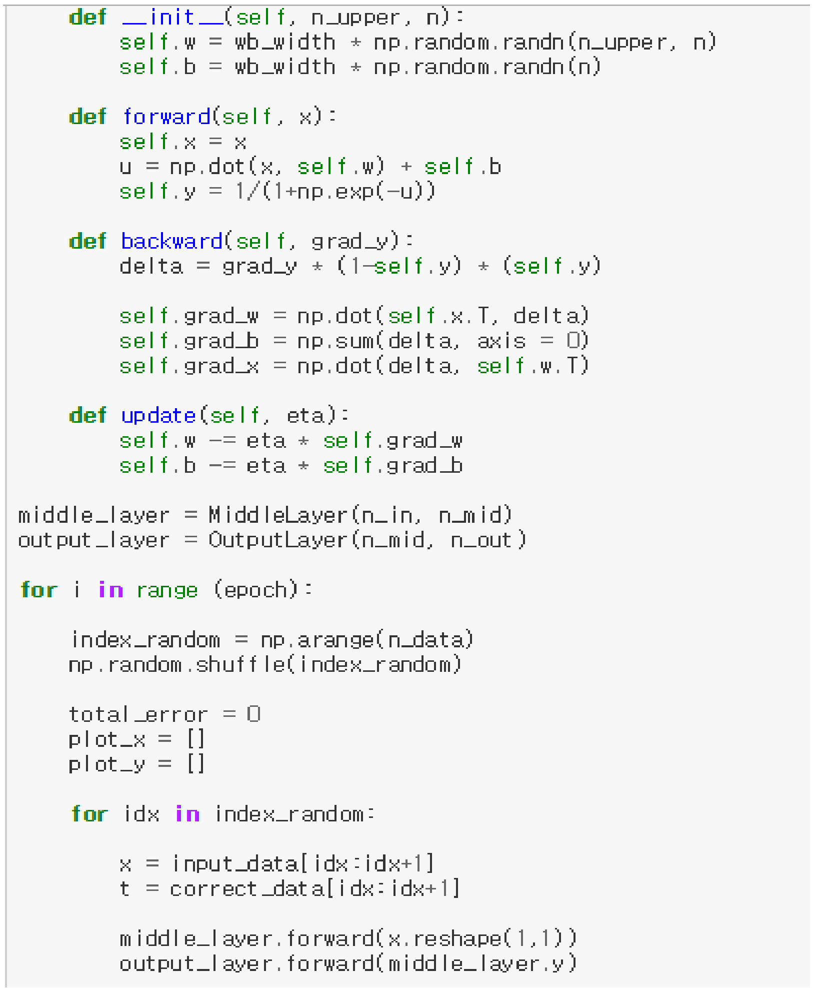
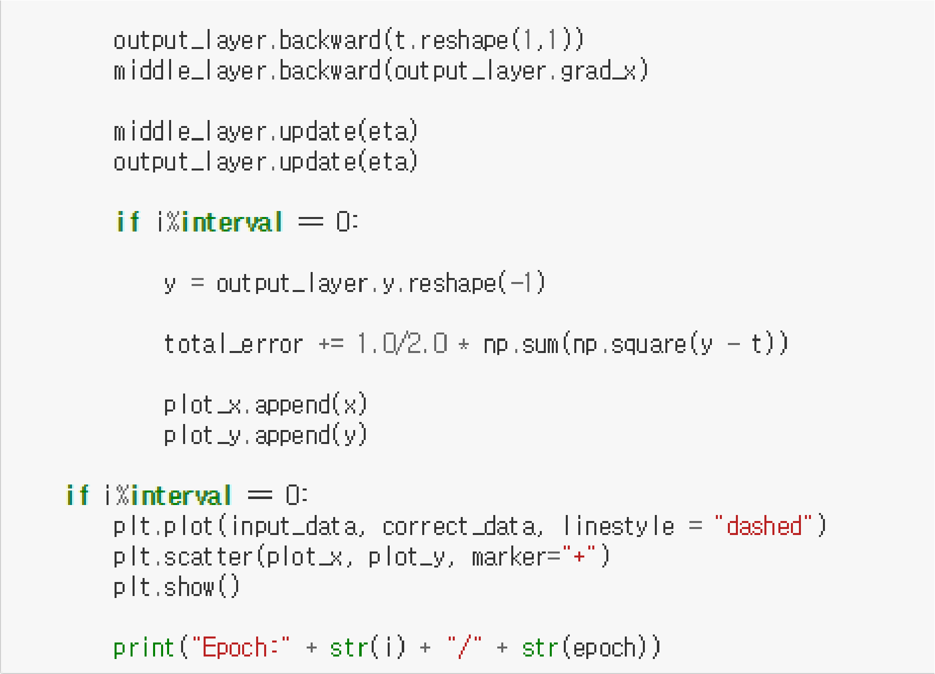


```
%matplotlib inline

import numpy as np
import matplotlib.pyplot as plt

input_data = np.arange(0, 2*np.pi, 0.1)
correct_data = np.cos(input_data)
input_data = (input_data) / np.pi
n_data = len(correct_data)

n_in = 1
n_mid = 3
n_out = 1

wb_width = 0.01
eta = 0.1
epoch = 2001
interval = 200

class OutputLayer:
    def __init__(self, n_upper, n):
        self.w = wb_width * np.random.randn(n_upper, n)
        self.b = wb_width * np.random.randn(n)

    def forward(self, x):
        self.x = x
        u = np.dot(x, self.w) + self.b
        self.y = u

    def backward(self, t):
        delta = self.y - t

        self.grad_w = np.dot(self.x.T, delta)
        self.grad_b = np.sum(delta, axis=0)
        self.grad_x = np.dot(delta, self.w.T)

    def update(self, eta):
        self.w -= eta * self.grad_w
        self.b -= eta * self.grad_b

class MiddleLayer:
```



```
    def __init__(self, n_upper, n):
        self.w = wb_width * np.random.randn(n_upper, n)
        self.b = wb_width * np.random.randn(n)

    def forward(self, x):
        self.x = x
        u = np.dot(x, self.w) + self.b
        self.y = 1/(1+np.exp(-u))

    def backward(self, grad_y):
        delta = grad_y * (1-self.y) * (self.y)

        self.grad_w = np.dot(self.x.T, delta)
        self.grad_b = np.sum(delta, axis = 0)
        self.grad_x = np.dot(delta, self.w.T)

    def update(self, eta):
        self.w -= eta * self.grad_w
        self.b -= eta * self.grad_b

middle_layer = MiddleLayer(n_in, n_mid)
output_layer = OutputLayer(n_mid, n_out)

for i in range (epoch):

    index_random = np.arange(n_data)
    np.random.shuffle(index_random)

    total_error = 0
    plot_x = []
    plot_y = []

    for idx in index_random:

        x = input_data[idx:idx+1]
        t = correct_data[idx:idx+1]

        middle_layer.forward(x.reshape(1,1))
        output_layer.forward(middle_layer.y)
```



```
        output_layer.backward(t.reshape(1,1))
        middle_layer.backward(output_layer.grad_x)

        middle_layer.update(eta)
        output_layer.update(eta)

        if i%interval == 0:

            y = output_layer.y.reshape(-1)

            total_error += 1.0/2.0 * np.sum(np.square(y - t))

            plot_x.append(x)
            plot_y.append(y)

    if i%interval == 0:
        plt.plot(input_data, correct_data, linestyle = "dashed")
        plt.scatter(plot_x, plot_y, marker="+")
        plt.show()

        print("Epoch:" + str(i) + "/" + str(epoch))
```

◎손실 함수 : 오차제곱합

◎은닉층 활성화 함수 : 시그모이드 함수

◎출력층 활성화 함수 : 항등 함수