MidTerm Assignment: notebook 2: Backpropagation (Total 25pts)

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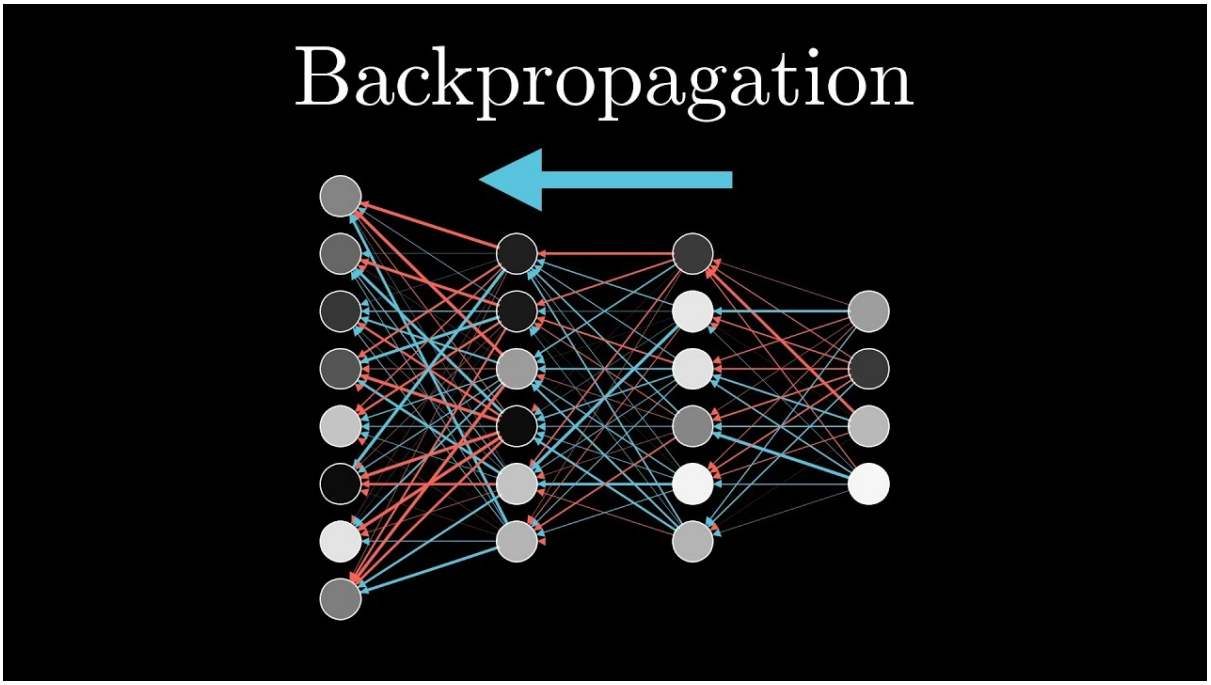
In [501]:
```
#<img src="backpro.png" width="800" />
from IPython.display import Image
Image('backpro.png')
```

Out[501]:

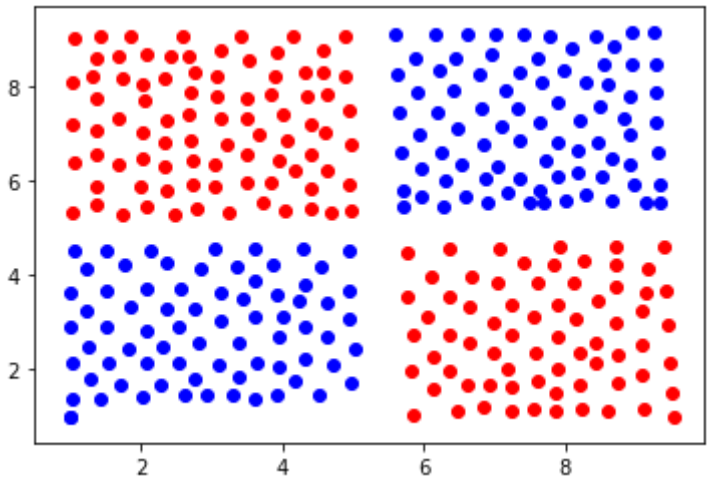


Question 1. Training the network through backpropagation (Total 22pts)

In this exercise, you will get to apply what you learned on backpropagation. We are interested in learning a classifier for the dataset below. This dataset is similar to what we did in class in the on hidden layer case. The difference is that you now have to learn a neural network with **multiple hidden layers**. We want to train the network through a minimization of the binary cross entropy. We further want to consider an ℓ_2-regularizarion term on all the weights except the bias, of each neurons.

In [450]:
```
import matplotlib.pyplot as plt
import numpy as np
import scipy.io as sio

data_class1 = sio.loadmat('Notebook1_Ex1_Class1.mat')
data_class2 = sio.loadmat('Notebook1_Ex1_Class2.mat')

data_class1 = data_class1['Notebook1_Ex1_Class1']
data_class2 = data_class2['Notebook1_Ex1_Class2']

add_value = [[1,1],[1,1]]
data_class2 = np.vstack((data_class2,add_value))

print("Shape of Class 1: ",np.shape(data_class1))
print("Shape of Class 2: ",np.shape(data_class2))

plt.scatter(data_class1[:,0], data_class1[:,1], c = 'r')
plt.scatter(data_class2[:,0], data_class2[:,1], c='b')

plt.show()
```

```
Shape of Class 1:  (156, 2)
Shape of Class 2:  (156, 2)
```

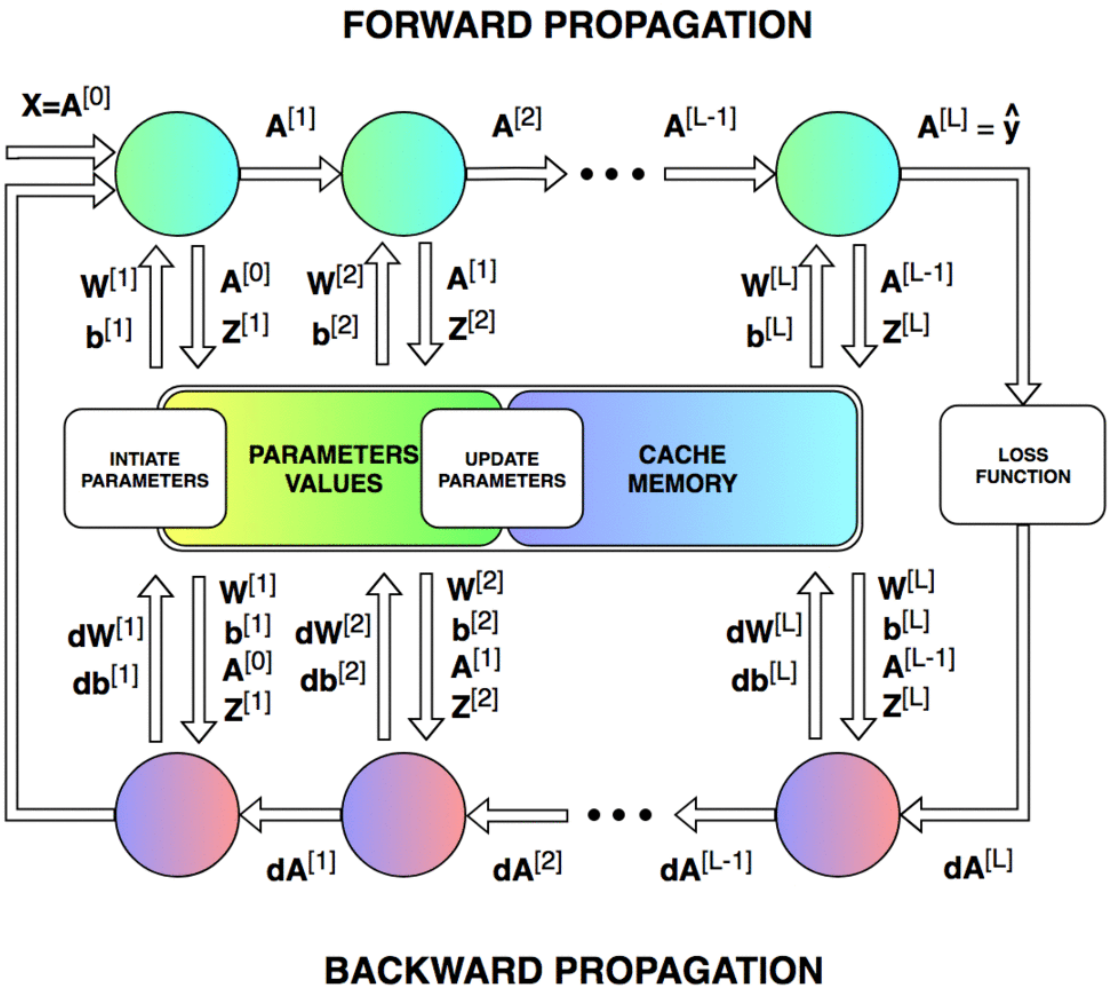


Solution BluePrint

This GIF Is the roadmap for Forward and Backward Propagation

In [502]:
```
Image('blueprint.gif.png')
```

Out[502]:



Question 1.1. (3pts) Start by coding the sigmoid activation function and its derivative

Solution

1.1.1 Mathematical Base

1. we define our **Sigmoid Activation Function** as:

$$h_{(\beta)}(z) = \sigma(z) = \sigma(\beta^T \tilde{\mathbf{x}}) = \frac{1}{1 + e^{-z}} = \frac{1}{1 + e^{-\beta^T x}}$$

1. Take **Derivative** of our **Sigmoid Activation Function** as:

$$\nabla(\sigma(z)) = \frac{d}{d(z)}\sigma(z) = \sigma(z) * (1 - \sigma(z))$$

Read **this document (https://towardsdatascience.com/derivative-of-the-sigmoid-function-536880cf918e)** for Detail mathematics of how to find Sigmoid Derivative HERE

$$x = z$$

In [503]:
```
Image('sigmoid_derivative.png')
```

Out[503]:

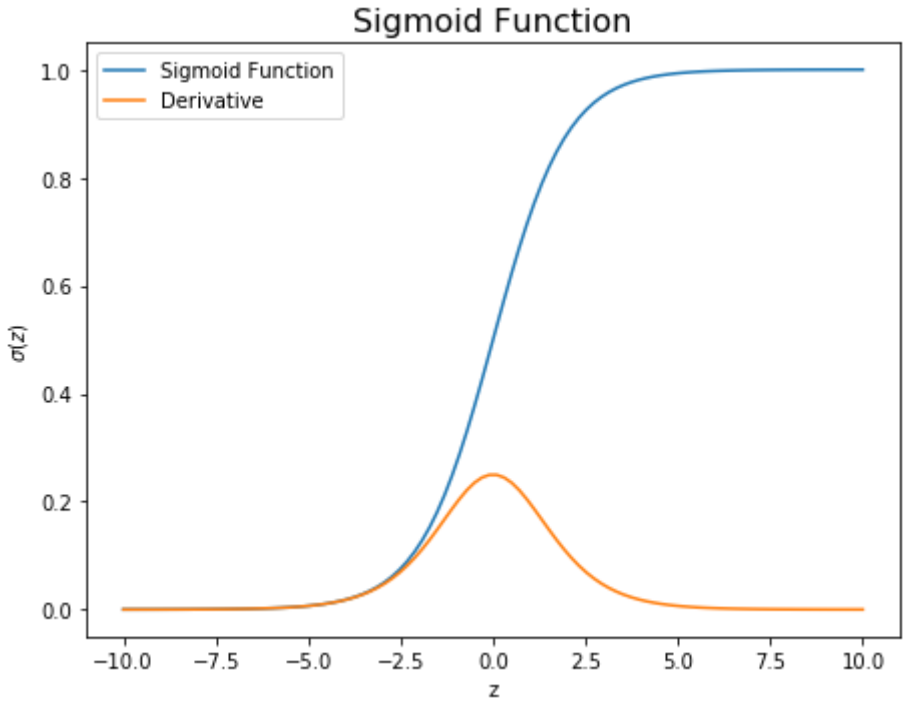
$$
\begin{aligned}
\frac{d}{dx}\sigma(x) &= \frac{d}{dx}\left[\frac{1}{1+e^{-x}}\right] \\
&= \frac{d}{dx}\left(1+\mathrm{e}^{-x}\right)^{-1} \\
&= -(1+e^{-x})^{-2}(-e^{-x}) \\
&= \frac{e^{-x}}{(1+e^{-x})^2} \\
&= \frac{1}{1+e^{-x}} \cdot \frac{e^{-x}}{1+e^{-x}} \\
&= \frac{1}{1+e^{-x}} \cdot \frac{(1+e^{-x})-1}{1+e^{-x}} \\
&= \frac{1}{1+e^{-x}} \cdot \left(\frac{1+e^{-x}}{1+e^{-x}} - \frac{1}{1+e^{-x}}\right) \\
&= \frac{1}{1+e^{-x}} \cdot \left(1 - \frac{1}{1+e^{-x}}\right) \\
&= \sigma(x) \cdot (1-\sigma(x))
\end{aligned}
$$

1.1.2 Programming

In [451]:
```
# ============================================================================
==========================
# Step I : Activation
# ============================================================================
==========================

''' Activation Function'''
def sigmoid(z):
    sigmoid  = np.true_divide(1, (1+np.exp(-z)))
    return sigmoid

'''Derivative of the Activation Function'''
def sigmoid_derivative(z):
    sig_value = sigmoid(z)
    sigmoid_derivative = np.multiply(sig_value, (1 - sig_value))

    return sigmoid_derivative
```

Extra Work: This is how Sigmoid function and its derivative Graphically looks like

In [452]:
```
def plot_sigmoid_derivative(z):

    A_sigmoid = sigmoid(z)
    A_derivative = sigmoid_derivative(z)

    plt.figure(figsize=(16, 12))
    plt.subplot(2, 2, 1)

    plt.plot(z, A_sigmoid, label="Sigmoid Function")
    plt.plot(z, A_derivative, label = "Derivative")
    plt.legend(loc="upper left")
    plt.xlabel("z")
    plt.ylabel(r"$\sigma(z)$")
    plt.title("Sigmoid Function", fontsize=16)

    plt.show()

''' Change Input values here'''
z = np.linspace(-10, 10, 100)
plot_sigmoid_derivative(z)
```



Initializing the Network Size at the start

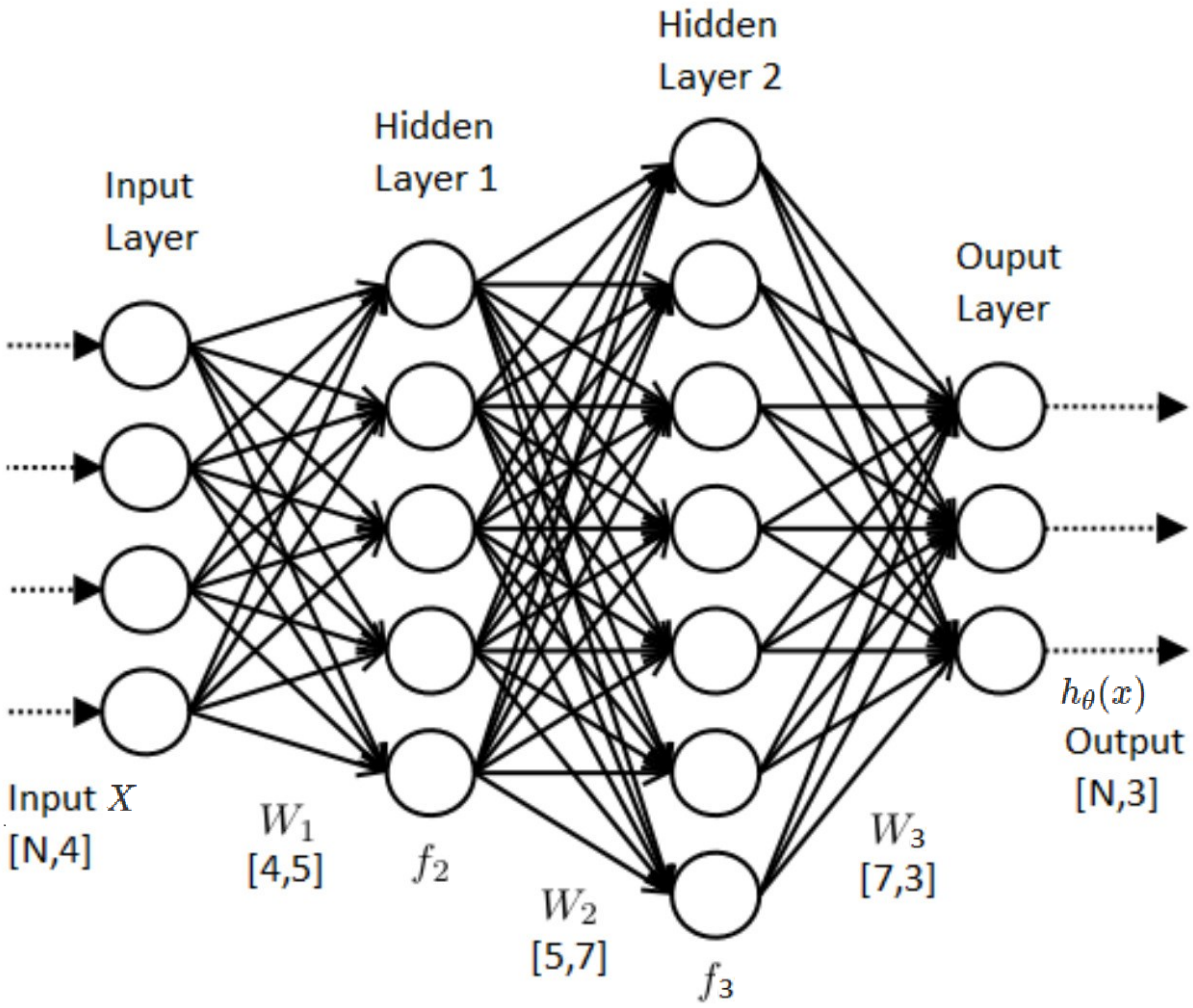
In [453]:
```
'''Our Network has 2 input Neurons, and 1 output Neuron'''
''' Four Hidden Layers'''
'''First Hidden Layer has 15 nodes, second hidden layer 25'''
'''Third Layer has 25 nodes Fourth Layer has nodes 10'''

Network_size = [
    {"input_dim": 2, "output_dim": 15, "activation": "sigmoid"},
    {"input_dim": 15, "output_dim": 25, "activation": "sigmoid"},
    {"input_dim": 25, "output_dim": 25, "activation": "sigmoid"},
    {"input_dim": 25, "output_dim": 10, "activation": "sigmoid"},
    {"input_dim": 10, "output_dim": 1, "activation": "sigmoid"},
]
print("\033[1m"+"\n\t\t\t\tOur Neural Network size {} \n\n{}".format("\033[0m",Network_size))
```

Our Neural Network size

```
[{'input_dim': 2, 'output_dim': 15, 'activation': 'sigmoid'}, {'input_dim': 15, 'output_dim': 25, 'activation': 'sigmoid'}, {'input_dim': 25, 'output_dim': 25, 'activation': 'sigmoid'}, {'input_dim': 25, 'output_dim': 10, 'activation': 'sigmoid'}, {'input_dim': 10, 'output_dim': 1, 'activation': 'sigmoid'}]
```

In [504]:
```
#<img src="NN.png" width="600" />
Image("NN.png")
```

Out[504]:



Initialize Weights for Each Nodes in Layers

1. Randomly Prepared parameters values are stored in a python dictionary with a key that uniquely identifies to which layer they belong.
2. The dictionary is returned at the end of the function, so we can use it in the next stages of our Neural Network

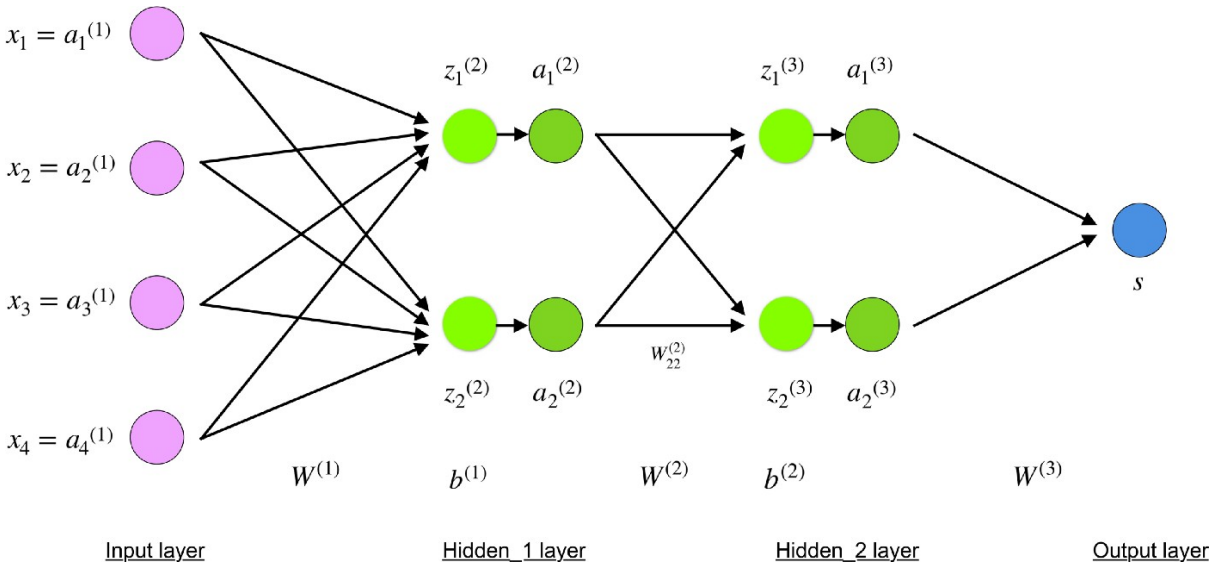
In [454]:
```
def weights_layer(Network_size, seed = 100):
    np.random.seed(seed)
    num_layers = len(Network_size)
    parameters = {}

    for index, layer in enumerate(Network_size):
        layer_index = index + 1
        '''Num of Units in Layers'''
        layer_input_size = layer["input_dim"]
        layer_output_size = layer["output_dim"]

        '''Weight matrix and bias vectors'''
        parameters['Weight' + str(layer_index)] = np.random.randn(layer_
output_size, layer_input_size) * 0.1
        parameters['bias' + str(layer_index)] = np.random.randn(layer_ou
tput_size, 1)*0.1

    return parameters
```

Question 1.2. (6pts) Code the forward propagation of an input X through a network with weights W

Solution 1.2

In [505]:
```
#<img src="neural_network.jpeg" width="600" />
Image("neural_network.png")
```

Out[505]:



In [506]:
```
#<img src="forward_propa.png" width="600" />
Image("forward_propa.png")
```

Out[506]:

$$x = a^{(1)} \qquad Input\ layer$$

$$z^{(2)} = W^{(1)}x + b^{(1)} \qquad neuron\ value\ at\ Hidden_1\ layer$$

$$a^{(2)} = f(z^{(2)}) \qquad activation\ value\ at\ Hidden_1\ layer$$

$$z^{(3)} = W^{(2)}a^{(2)} + b^{(2)} \qquad neuron\ value\ at\ Hidden_2\ layer$$

$$a^{(3)} = f(z^{(3)}) \qquad activation\ value\ at\ Hidden_2\ layer$$

$$s = W^{(3)}a^{(3)} \qquad Output\ layer$$

Read [this document (https://towardsdatascience.com/forward-propagation-in-neural-networks-simplified-math-and-code-version-bbcfef6f9250)](https://towardsdatascience.com/forward-propagation-in-neural-networks-simplified-math-and-code-version-bbcfef6f9250) for mathematics of how to do forward propagation

Mathematical Base

1. Calculate $\boldsymbol{Z}^{[l]}$ by following equation:

$$\boldsymbol{Z}^{[l]} = \boldsymbol{W}^{[l]} \cdot \boldsymbol{A}^{[l-1]} + \boldsymbol{b}^{[l]}$$

1. Calculate $\boldsymbol{A}^{[l]}$ by using $\boldsymbol{Z}^{[l]}$ and Sigmoid Activation function

$$\boldsymbol{A}^{[l]} = g^{[l]}(\boldsymbol{Z}^{[l]})$$

1. For multi-layer NN, we have single forward propagation and complete forward propagation. In complete forward propagation, we call our single forward propagation for each node of each layer. This makes it a little easier to compute $\boldsymbol{Z}^{[l]}$ and $\boldsymbol{A}^{[l]}$

Programming

In [455]:
```
def simple_forward_propa(prev_Act_vect, weight_curr, bias_curr, activati
on_curr):

    activ_input = np.dot(weight_curr, prev_Act_vect) + bias_curr

    return sigmoid(activ_input), activ_input
```

In [456]:
```
# ============================================================================
============================
# Step II : Forward Propagation
# ============================================================================
============================

def Forward_propagation_complete(X, parameters, Network_size):
    '''Memory to store information from Backpropagation Store'''
    memory = {}
    X_vect_Act = X

    for index, layer in enumerate(Network_size):
        layer_index = index + 1 # starting index from 1
        prev_Act_vect = X_vect_Act # transforming activation across laye
rs

        activation_curr = layer["activation"]
        weight_curr = parameters["Weight" + str(layer_index)]
        bias_curr = parameters["bias" + str(layer_index)]
#         print("activation for layer {} is: {}".format(layer, activatio
n_curr))

        X_vect_Act, activ_input = simple_forward_propa(prev_Act_vect, we
ight_curr, bias_curr, activation_curr)

        memory["A" + str(index)] = prev_Act_vect
        memory["Z" + str(layer_index)] = activ_input

    predict_vector = X_vect_Act
    print("Shape of Prediction Vector: {} \nMemory dictionary size: {}".
format(predict_vector.shape, len(memory)))
    print("Prediction Vector is: \n{}".format(predict_vector))
    return predict_vector, memory
```

Question 1.3. (9pts) code the log-loss and its derivative through backpropagation

Solution

I.3.1 Mathematical Base

LogLoss Function

Our Goal is: $0 \leq h_\beta(x) \leq 1$

Previously, we have defined our __Sigmoid Function as:

$$h_{(\beta)}(x) = \sigma(\beta^T \tilde{\mathbf{x}}) = \frac{1}{1 + e^{-\beta^T x}}$$

Assign **discrete value** of 0 or 1 to our dataset:

$$h_\beta(x) \geq 0.5 \Rightarrow t = 1$$
$$h_\beta(x) < 0.5 \Rightarrow t = 0$$

Cost Function: Binary Cross Entropy/Log Loss

$$l_{(\beta)} = -\frac{1}{N} \sum_{i=1}^{N} (t^{(i)}(\log(h_\beta(x^{(i)})) + ((1 - t^{(i)})(\log(1 - h_\beta(x^{(i)}))$$

Vectorized form

$$h = \sigma(X\beta) = \frac{1}{1 + e^{-X\beta}}$$
$$l_{(\beta)} = \frac{1}{N}((-t^T \log(h)) - ((1 - t)^T log(1 - h)))$$

Regularized Loss Function for Backpropagation

$$l_{(\beta)} = -\frac{1}{N} \sum_{i=1}^{N} \sum_{k=1}^{K} \left[(t_k^{(i)}(\log(h_\beta(x^{(i)})_k) + ((1 - t_k^{(i)})(\log(1 - h_\beta(x^{(i)})_k) \right] + \frac{\lambda}{dN} \sum_{l=1}^{L-1} \sum_{i=1}^{S_l} \sum_{j=1}^{S_{l+1}} (\beta_{j,i}^{(l)})^2$$

Programming

In [457]:
```
def LogLoss(y_hat, t):
    N = y_hat.shape[1]
    loss = np.true_divide(-1,N) * (np.dot(t, np.log(y_hat)) + np.dot(1-t
, 1-np.log(1-y_hat)))
    loss = np.squeeze(loss)

    '''For Regularized LossLog Value. Comment out and Change Beta value
s'''
#     loss = sum(loss)

#     if (regularized == True):
#         summation = (np.sum(np.power(beta_1[:1:], 2)) + np.sum(np.powe
r(beta_2[:1:], 2)) + np.sum(np.power(beta_3[:1:], 2)))
#         lambda_by_dN = (float(learning_rate) / (2*num_instances))
#         loss +=  np.multiply(lambda_by_dN,summation)

    return loss
```

Mathematical Base

Find Gradient using backpropagation

Given training set $[(x^1, t^1), \ldots, (x^N, t^N)]$

1. **Step 01**:

   For all i, j, l set

   $$\triangle_{i,j}^{(l)} := 0$$

   `__For Example__ for y = 1 to N`

   $$a^{(1)} := x^{(y)}$$

1. **Step 02**:

   Perform Forward Propagation to compute $a^{(l)}$ for $l = 2, 3, 4, \ldots, L$

1. **Step 03**:

   $$error = \delta^{(L)} = a^{(L)} - t^{(y)}$$

2. **Step 04**:

   Compute $\delta^{(L-1)}, \delta^{(L-2)}, \ldots, \delta^{(2)}$ using

   $$\delta^{(l)} = ((\beta^{(l)})^T \delta^{(l+1)}) .* g^{'}(z^{(l)}))$$

   where

   $$g^{'}(z^{(l)}) = a^{(l)} .* (1 - a^{(l)})$$

3. **Step 05**:

   $$\triangle_{i,j}^{(l)} := \triangle_{i,j}^{(l)} + a_j^{(l)} \delta_j^{(l+1)}$$

   Vectorized Form

   $$\triangle^{(l)} := \triangle^{(l)} + \delta^{(l+1)} (a^{(l)})^T$$

4. **Step 06**:

   Update $\triangle$ matrix

   when $j \; ! = 0$

   $$D_{i,j}^{(l)} := \frac{1}{N} (\triangle_{i,j}^{(l)} + \lambda \beta_{i,j}^{(l)})$$

   when $j = 0$

   $$D_{i,j}^{(l)} := \frac{1}{N} (\triangle_{i,j}^{(l)})$$

5. **Step 07**:

Thus,

$$\frac{\partial}{\partial \beta_{i,j}^{(l)}} l_{(\beta)} = D_{i,j}^{(l)}$$

I.3.2 Programming

In [458]:
```
def simple_back_propa(gradient_curr,weight_curr,bias_curr,Z_curr,A_prev,
curr_activ):
    N = A_prev.shape[1]

    Z_grad = sigmoid_derivative(Z_curr)

    grad_weight = np.true_divide(np.dot(Z_grad,A_prev.T),N)
    grad_bias = np.true_divide(np.sum(Z_grad, axis =1, keepdims = True),
N)
    gradient_prev = np.dot(weight_curr.T, Z_grad)
#     gradient_prev = gradient_curr

    return gradient_prev, grad_weight, grad_bias
```

In [459]:
```
def Back_propagation_complete(y_hat, t, memory, parameters, Network_size
):
    gradient = {}
    N = t.shape[1]
#     t = t.reshape(y_hat.shape[1])

    gradient_prev = - (np.divide(t,y_hat) - np.divide(1-t, 1-y_hat))

    for prev_layer_index, layer in reversed(list(enumerate(Network_size
))):

        current_layer_index = prev_layer_index + 1
        curr_activ = layer["activation"]

        gradient_curr = gradient_prev

        A_prev = memory["A" + str(prev_layer_index)]
        Z_curr = memory["Z" + str(current_layer_index)]

        weight_curr = parameters["Weight" + str(current_layer_index)]
        bias_curr = parameters["bias" + str(current_layer_index)]

        gradient_prev, grad_weight, grad_bias = simple_back_propa(
            gradient_curr,weight_curr,bias_curr,Z_curr,A_prev,curr_activ
)

        gradient["Grad_Weight" + str(current_layer_index)] = grad_weight
        gradient["Grad_bias" + str(current_layer_index)] = grad_bias

        print("\033[1m"+"\t\t\t\tFrom Back Propagation"+"\033[0m")
        print("==========================================================
======================================")
        print("\nShape of A{} is {} and A{} values are: \n{}\n".format(p
rev_layer_index, A_prev.shape,prev_layer_index,A_prev))
        print("\nShape of Z{} is {} and Z{} values are: \n{}\n".format(c
urrent_layer_index, Z_curr.shape, current_layer_index,Z_curr))
        print("Shape of Current Weights: {}\nShape of Current Bias: \
        {}".format(weight_curr.shape,bias_curr.shape))
        print("==========================================================
======================================")

    return gradient
```

Update Parameters

Using Gradient values from Back Propagation to update our Parameters

In [460]:
```
def weight_grad_update(parameters, gradient, Network_size, learning_rate
):

    for layer_index, layer in enumerate(Network_size, 1):
        parameters["Weight" + str(layer_index)] -= learning_rate * gradi
ent["Grad_Weight" + str(layer_index)]
        parameters["bias" + str(layer_index)] -= learning_rate * gradien
t["Grad_bias" + str(layer_index)]

    return parameters
```

Question 1.4. (4pts) Train your network using the minimize module from scipy.

This modules requires you to specify the function Logloss wihch you coded above. The 'jac=True'parameter simply indicates that your function 'Logloss' should return both the loss that you want to minimize and the gradient of that loss. Minimize then apply gradient descent or a related optimization routine to this function.

Solution

To train our model:

```
1. randomly initiate parameters by calling weights_layer() function
2. for each Epoch
    2.1 Do forward propagation to get y_hat i.e. new y predicted val
ues
    2.2 Find new gradient using Back-Propagation
    2.3 Update the Parameters using new gradient
```

In [467]:
```
def train_model(X, t, Network_size, epochs, learning_rate):
    parameters = weights_layer(Network_size, 2)

    cost_history = []

    for i in range(epochs):
        print("============================================================
======================================")
        print("\033[1m"+"\n\t\t\t\tFor Epoch {} and Learning Rate {}:\n"
.format(i, learning_rate)+"\033[0m")
        print("============================================================
======================================")
        y_hat, memory = Forward_propagation_complete(X, parameters, Netw
ork_size)
        print("Shape of Y_hat: {}\n".format(y_hat.shape))
        print("============================================================
======================================")

#         cost = LogLoss(y_hat, t)
#         cost_history.append(cost)

        gradient = Back_propagation_complete(y_hat, t, memory, parameter
s, Network_size)
        parameters = weight_grad_update(parameters, gradient, Network_si
ze, learning_rate)
    print("\n \t\t\t\tPrediction Vector is: \n{}\n".format(y_hat))
    return parameters, cost_history, y_hat, gradient
```

To see entire output, click on the left side of the output of the following cell. All values will show up.

```
Define X (input), t (target) and call train_model() function
```

In [468]:
```
X = np.vstack((data_class1[:,0],data_class2[:,0]))
t = np.vstack((data_class1[:,1],data_class2[:,1]))
parameters, cost_history, y_hat, gradient = train_model(X,t,Network_size
, 2, 0.1)

for i in parameters:
    print("==================================================================
==================================")
    print("\033[1m"+"\t\t\tUpdated Parameters are: "+"\033[0m" +"\n=====
==================================\
============================================================\n{}\n{}".form
at(i,parameters[i]))

print("\033[1m"+"\n==================================End of Output=======
====\
================================================="+"\033[0m")
```

```
================================================================================
========================
```

For Epoch 0 and Learning Rate 0.1:

```
================================================================================
========================
Shape of Prediction Vector: (1, 156)
Memory dictionary size: 10
Prediction Vector is:
[[0.45978053 0.45978221 0.45978444 0.45978758 0.45978952 0.45979102
  0.45979246 0.45979191 0.45979137 0.45979103 0.4597932  0.45977925
  0.45977867 0.45977814 0.45977768 0.45977895 0.45978106 0.45978315
  0.45978543 0.45978754 0.45978884 0.45979214 0.45979216 0.4597923
  0.45979234 0.45979205 0.45979156 0.45979269 0.45979395 0.45979515
  0.45979654 0.45979822 0.45979947 0.45979133 0.4597938  0.45979779
  0.45979896 0.4597999  0.45980024 0.4598     0.45980382 0.45980385
  0.45980393 0.45980369 0.45980372 0.45978117 0.4597806  0.45978012
  0.4597827  0.45978257 0.4597819  0.45978361 0.45978183 0.45978197
  0.45978387 0.45978341 0.45978339 0.45978518 0.45978507 0.45978464
  0.45978693 0.45978694 0.45978691 0.45979238 0.4597923  0.45979245
  0.45979257 0.45979388 0.45979376 0.45979373 0.45979361 0.45979495
  0.4597967  0.4597998  0.45979985 0.45979985 0.4598011  0.4598011
  0.45980072 0.45980213 0.45980201 0.45980206 0.4598022  0.45980269
  0.45980266 0.45980266 0.45980267 0.45980235 0.45977931 0.45978118
  0.45978331 0.45978497 0.45978702 0.45978763 0.45979002 0.4597789
  0.45978091 0.45978263 0.45978407 0.45978797 0.45979064 0.45979123
  0.45978025 0.45978161 0.45978302 0.45978446 0.45978456 0.45978679
  0.45978512 0.45978698 0.45978772 0.45978643 0.45977729 0.45977883
  0.45978042 0.459782   0.45978355 0.45978229 0.45978402 0.45978632
  0.45978796 0.45979155 0.45979209 0.45979212 0.45979146 0.45979144
  0.45979287 0.45979242 0.4597939  0.45979564 0.45979665 0.45979384
  0.45979296 0.45979562 0.45979661 0.45979715 0.45979566 0.45979582
  0.45979709 0.45979971 0.45979974 0.45979882 0.45979976 0.45980105
  0.45980074 0.45979985 0.4598014  0.4598014  0.45980246 0.45980115
  0.45980141 0.45980199 0.45980258 0.45980063 0.4597795  0.45978001]]
Shape of Y_hat: (1, 156)

================================================================================
========================
```

From Back Propagation

```
================================================================================
========================

Shape of A4 is (10, 156) and A4 values are:
[[0.49447586 0.49446429 0.49445114 ... 0.4943683  0.49456131 0.4945090
3]
 [0.51550185 0.51549601 0.51548727 ... 0.51540731 0.51547541 0.5154923
1]
 [0.43934287 0.4393506  0.43935933 ... 0.43940237 0.43928981 0.4393223
5]
 ...
 [0.56615747 0.56616151 0.56616803 ... 0.56621602 0.56619987 0.5661731
6]
 [0.57211629 0.57211386 0.5721081  ... 0.57202037 0.57204348 0.5720890
8]
 [0.57137053 0.57137597 0.57138385 ... 0.57144799 0.57139119 0.571378
```

```
 ]]


Shape of Z5 is (1, 156) and Z5 values are:
[[-0.1612262  -0.16121943 -0.16121047 -0.16119785 -0.16119003 -0.161183
99
  -0.1611782  -0.1611804  -0.16118259 -0.16118394 -0.16117521 -0.161231
36
  -0.16123372 -0.16123583 -0.16123769 -0.16123256 -0.16122408 -0.161215
68
  -0.1612065  -0.16119798 -0.16119276 -0.16117946 -0.1611794  -0.161178
84
  -0.16117866 -0.16117984 -0.16118183 -0.16117725 -0.16117218 -0.161167
35
  -0.16116175 -0.16115499 -0.16114996 -0.16118274 -0.16117279 -0.161156
74
  -0.16115201 -0.16114823 -0.16114685 -0.16114783 -0.16113244 -0.161132
32
  -0.16113199 -0.16113297 -0.16113284 -0.16122362 -0.16122594 -0.161227
87
  -0.16121749 -0.161218   -0.16122069 -0.16121381 -0.161221   -0.161220
42
  -0.16121276 -0.16121461 -0.16121471 -0.16120751 -0.16120793 -0.161209
68
  -0.16120046 -0.1612004  -0.16120052 -0.16117852 -0.16117882 -0.161178
22
  -0.16117773 -0.16117247 -0.16117294 -0.16117306 -0.16117354 -0.161168
16
  -0.16116113 -0.16114865 -0.16114845 -0.16114845 -0.1611434  -0.161143
4
  -0.16114495 -0.16113923 -0.16113973 -0.16113955 -0.16113896 -0.161136
99
  -0.16113712 -0.16113712 -0.16113708 -0.16113839 -0.16123114 -0.161223
61
  -0.16121502 -0.16120834 -0.1612001  -0.16119763 -0.16118801 -0.161232
76
  -0.16122469 -0.16121775 -0.16121195 -0.16119625 -0.16118551 -0.161183
15
  -0.16122733 -0.16122186 -0.16121617 -0.1612104  -0.16121001 -0.161201
  -0.16120774 -0.16120025 -0.16119728 -0.16120248 -0.16123925 -0.161233
08
  -0.16122668 -0.16122031 -0.16121406 -0.16121914 -0.16121215 -0.161202
89
  -0.1611963  -0.16118183 -0.16117966 -0.16117954 -0.16118223 -0.161182
29
  -0.16117654 -0.16117834 -0.16117241 -0.16116537 -0.16116132 -0.161172
65
  -0.16117616 -0.16116548 -0.16116147 -0.1611593  -0.1611653  -0.161164
67
  -0.16115956 -0.16114898 -0.16114888 -0.16115257 -0.16114878 -0.161143
62
  -0.16114487 -0.16114841 -0.16114218 -0.16114221 -0.16113793 -0.161143
2
  -0.16114214 -0.1611398  -0.16113744 -0.16114531 -0.16123035 -0.161228
3 ]]

Shape of Current Weights: (1, 10)
```

```
Shape of Current Bias:         (1, 1)
==========================================================================
=========================
                                 From Back Propagation
==========================================================================
=========================

Shape of A3 is (25, 156) and A3 values are:
[[0.41715484 0.41720752 0.41727042 ... 0.41768459 0.41688695 0.4170495
6]
 [0.37061565 0.37062426 0.37064432 ... 0.37088166 0.37091681 0.3707282
1]
 [0.4241221  0.42446471 0.42492285 ... 0.42865808 0.4238644  0.4239991
4]
 ...
 [0.55074308 0.55068059 0.55059816 ... 0.54989404 0.55086013 0.5507920
5]
 [0.52759713 0.52760712 0.52759382 ... 0.52728988 0.52664721 0.5272372
4]
 [0.47125484 0.47127136 0.47131562 ... 0.47185458 0.47201099 0.4715390
4]]


Shape of Z4 is (10, 156) and Z4 values are:
[[-0.02209745 -0.02214373 -0.02219633 ... -0.02252774 -0.02175564
  -0.02196475]
 [ 0.06202729  0.06200391  0.0619689  ...  0.06164877  0.06192144
   0.06198908]
 [-0.24382941 -0.24379804 -0.24376258 ... -0.24358785 -0.24404482
  -0.24391272]
 ...
 [ 0.26619061  0.26620708  0.26623363 ...  0.26642899  0.26636325
   0.26625451]
 [ 0.29049083  0.2904809   0.29045735 ...  0.29009898  0.2901934
   0.29037965]
 [ 0.28744508  0.28746728  0.28749948 ...  0.28776138  0.28752945
   0.28747557]]

Shape of Current Weights: (10, 25)
Shape of Current Bias:         (10, 1)
==========================================================================
=========================
                                 From Back Propagation
==========================================================================
=========================

Shape of A2 is (25, 156) and A2 values are:
[[0.52574986 0.52717875 0.52907898 ... 0.54316395 0.52510894 0.5253978
8]
 [0.42583675 0.42663261 0.42778789 ... 0.43839207 0.42820731 0.4266687
2]
 [0.45966919 0.4585055  0.45711729 ... 0.44820415 0.46573024 0.4620382
6]
 ...
 [0.52819781 0.52769689 0.52701043 ... 0.5199084  0.52873684 0.5284397
4]
 [0.63752145 0.63674559 0.63558255 ... 0.62352317 0.63465861 0.6364994
```

```
 ]
 [0.45706862 0.45757706 0.45836042 ... 0.4642241  0.46107317 0.4585384
5]]


Shape of Z3 is (25, 156) and Z3 values are:
[[-0.33446408 -0.33424743 -0.33398873 ... -0.33228567 -0.335566
  -0.33489712]
 [-0.52957658 -0.52953968 -0.52945365 ... -0.52843633 -0.52828571
  -0.52909405]
 [-0.30587427 -0.30447168 -0.30259659 ... -0.28732826 -0.30692945
  -0.30637772]
 ...
 [ 0.2036735   0.20342092  0.20308781 ...  0.20024257  0.20414656
   0.20387141]
 [ 0.11050083  0.1105409   0.11048754 ...  0.10926813  0.10668992
   0.10905694]
 [-0.11510757 -0.11504129 -0.11486364 ... -0.11270081 -0.11207321
  -0.11396704]]

Shape of Current Weights: (25, 25)
Shape of Current Bias:         (25, 1)
==========================================================================
========================
                                 From Back Propagation
==========================================================================
========================

Shape of A1 is (15, 156) and A1 values are:
[[0.48081301 0.48041193 0.47953821 ... 0.46815122 0.4701164  0.4768192
8]
 [0.54272835 0.56244379 0.58737651 ... 0.76690134 0.48512494 0.5195653
3]
 [0.37250007 0.3645253  0.35248291 ... 0.24269915 0.33122244 0.3573336
3]
 ...
 [0.4384411  0.43598187 0.43237218 ... 0.39767757 0.43014107 0.4355072
4]
 [0.49509174 0.48192143 0.46350762 ... 0.30400546 0.48026593 0.4905415
6]
 [0.49518157 0.49424965 0.49186281 ... 0.45835207 0.45865457 0.4814912
7]]


Shape of Z2 is (25, 156) and Z2 values are:
[[ 0.10309063  0.10882225  0.11644734 ...  0.17308665  0.10052032
   0.10167903]
 [-0.2988577  -0.29560344 -0.29088226 ... -0.24769031 -0.28916903
  -0.29545582]
 [-0.16167447 -0.16636064 -0.17195328 ... -0.20792934 -0.13729428
  -0.15213975]
 ...
 [ 0.11291106  0.11090107  0.10814699 ...  0.07967573  0.11507418
   0.11388186]
 [ 0.56462261  0.56126676  0.55624191 ...  0.50452941  0.55225502
   0.56020252]
 [-0.1721494  -0.17010071 -0.16694499 ... -0.14334858 -0.15602307
```

```
  -0.1662279 ]]

Shape of Current Weights: (25, 15)
Shape of Current Bias:         (25, 1)
==========================================================================
=========================
                                 From Back Propagation
==========================================================================
=========================

Shape of A0 is (2, 156) and A0 values are:
[[1.05414747 1.03110599 1.03110599 1.05414747 1.03110599 1.86059908
  2.59792627 3.42741935 4.16474654 4.87903226 1.74539171 2.48271889
  3.24308756 4.04953917 4.69470046 4.90207373 4.94815668 4.97119816
  4.94815668 4.97119816 5.75460829 5.77764977 5.84677419 5.82373272
  5.84677419 6.35368664 7.06797235 7.92050691 8.72695853 9.39516129
  9.41820276 9.44124424 9.48732719 9.51036866 9.53341014 6.46889401
  7.25230415 7.87442396 8.61175115 9.11866359 1.74539171 1.67626728
  1.67626728 2.34447005 2.36751152 2.34447005 3.08179724 3.91129032
  3.05875576 3.12788018 4.00345622 3.95737327 6.35368664 6.35368664
  6.35368664 7.04493088 6.97580645 6.97580645 6.9297235  7.59792627
  7.57488479 7.55184332 7.59792627 8.12788018 8.15092166 8.19700461
  8.19700461 8.75       8.75       8.70391705 8.70391705 9.16474654
  9.07258065 1.37672811 1.37672811 1.37672811 1.37672811 1.37672811
  2.09101382 2.04493088 2.0218894  2.0218894  1.99884793 2.73617512
  2.71313364 2.71313364 2.69009217 3.54262673 3.49654378 3.49654378
  3.49654378 3.49654378 3.12788018 4.57949309 4.32603687 3.9343318
  4.34907834 4.39516129 4.39516129 4.39516129 3.8421659  3.05875576
  2.36751152 3.22004608 3.68087558 4.07258065 6.67626728 6.10023041
  6.05414747 6.12327189 6.12327189 6.63018433 6.65322581 6.65322581
  7.22926267 7.41359447 8.26612903 7.85138249 8.72695853 7.89746544
  7.89746544 7.89746544 7.18317972 7.22926267 8.42741935 8.45046083
  9.14170507 9.09562212 9.09562212 8.24308756 7.55184332 6.8375576
  8.42741935 7.22926267 7.87442396 4.64861751 4.60253456 4.62557604
  4.57949309 3.08179724 2.69009217 2.34447005 2.73617512 2.80529954
  3.72695853 4.39516129 4.18778802 3.8421659  2.75921659 2.43663594
  2.0218894  1.33064516 1.67626728 1.37672811 2.09101382 1.44585253]
 [1.05702765 1.51324885 2.13536866 3.04781106 3.62845622 4.29205069
  4.93490783 4.95564516 4.95564516 5.01785714 4.97638249 1.015553
  1.015553   1.03629032 1.03629032 1.43029954 2.03168203 2.63306452
  3.29665899 3.93951613 4.52016129 5.5985023  5.61923963 5.66071429
  5.68145161 5.70218894 5.70218894 6.2828341  6.90495392 7.48559908
  8.00403226 8.6468894  9.14458525 6.15841014 7.02937788 7.77592166
  8.4187788  8.93721198 9.24827189 9.26900922 9.26900922 9.26900922
  9.31048387 9.3312212  9.35195853 1.51324885 1.51324885 1.5547235
  2.09389401 2.07315668 2.07315668 2.55011521 2.52937788 2.57085253
  3.13076037 3.13076037 3.11002304 3.64919355 3.60771889 3.60771889
  4.31278802 4.31278802 4.31278802 6.22062212 6.19988479 6.26209677
  6.30357143 6.88421659 6.84274194 6.82200461 6.78052995 7.36117512
  7.98329493 7.34043779 7.36117512 7.36117512 7.90034562 7.90034562
  7.90034562 8.52246544 8.46025346 8.48099078 8.54320276 8.93721198
  8.91647465 8.91647465 8.91647465 8.95794931 1.24366359 1.76209677
  2.36347926 2.84043779 3.35887097 3.87730415 4.56163594 1.22292627
  1.86578341 2.36347926 2.77822581 3.93951613 4.64458525 4.64458525
  1.26440092 1.82430876 2.32200461 2.81970046 3.40034562 3.96025346
  3.44182028 4.02246544 4.25057604 3.96025346 1.28513825 1.72062212
  2.28052995 2.77822581 3.40034562 2.94412442 3.62845622 4.18836406
```

```
  4.70679724 5.88882488 5.90956221 5.93029954 5.97177419 5.97177419
  6.61463134 6.44873272 6.9671659  7.40264977 7.61002304 6.42799539
  6.49020737 7.15380184 7.67223502 7.09158986 6.53168203 6.59389401
  7.05011521 7.71370968 7.63076037 7.17453917 7.6514977  8.21140553
  8.29435484 8.08698157 8.68836406 8.60541475 8.83352535 8.16993088
  8.1906682  8.29435484 8.6468894  7.69297235 1.         1.        ]]


Shape of Z1 is (15, 156) and Z1 values are:
[[-0.07678568 -0.07839242 -0.08189289 ... -0.12756784 -0.11967702
  -0.09278942]
 [ 0.17133127  0.25108601  0.35313051 ...  1.19089636 -0.0595178
   0.07830131]
 [-0.52150634 -0.5557763  -0.60814307 ... -1.137938   -0.70266135
  -0.58695583]
 ...
 [-0.2474912  -0.25748572 -0.2721792  ... -0.41515136 -0.28127561
  -0.25941613]
 [-0.01963368 -0.07234582 -0.14622953 ... -0.82829614 -0.07897731
  -0.03783827]
 [-0.01927432 -0.0230024  -0.03255164 ... -0.1669786  -0.16576021
  -0.07406877]]

Shape of Current Weights: (15, 2)
Shape of Current Bias:         (15, 1)
==========================================================================
=========================
==========================================================================
=========================
```

For Epoch 1 and Learning Rate 0.1:

```
==========================================================================
=========================
Shape of Prediction Vector: (1, 156)
Memory dictionary size: 10
Prediction Vector is:
[[0.44068271 0.44068562 0.4406895  0.44069496 0.44069826 0.4407018
  0.44070494 0.44070498 0.44070497 0.44070528 0.44070522 0.44068265
  0.44068285 0.44068329 0.44068361 0.44068617 0.44068982 0.4406933
  0.44069692 0.44070023 0.44070318 0.44070778 0.44070786 0.44070803
  0.44070811 0.44070823 0.44070833 0.4407105  0.44071253 0.44071419
  0.44071549 0.44071696 0.44071799 0.44071039 0.44071297 0.44071512
  0.44071669 0.44071779 0.44071832 0.44071829 0.44072133 0.44072136
  0.44072148 0.44072118 0.44072122 0.44068578 0.44068595 0.44068648
  0.44068952 0.44068941 0.44068967 0.44069246 0.44069341 0.44069364
  0.44069663 0.44069699 0.44069685 0.44069953 0.44069931 0.44069964
  0.44070285 0.44070284 0.44070286 0.44071032 0.44071026 0.44071047
  0.44071061 0.44071247 0.44071235 0.44071229 0.44071216 0.44071385
  0.44071544 0.44071531 0.44071538 0.44071538 0.44071728 0.44071728
  0.440717   0.44071901 0.44071883 0.44071889 0.44071909 0.44071988
  0.44071983 0.44071983 0.44071984 0.44071951 0.44068438 0.44068761
  0.44069124 0.44069401 0.44069685 0.44069983 0.44070315 0.44068442
  0.44068856 0.44069152 0.4406939  0.44070011 0.44070351 0.44070351
  0.44068421 0.44068791 0.44069104 0.44069403 0.44069816 0.44070066
  0.44069809 0.44070097 0.44070204 0.44070086 0.44068644 0.44068902
  0.4406926  0.44069539 0.44069902 0.44069653 0.44070036 0.44070244
```

```
  0.44070464 0.44070915 0.4407091  0.44070919 0.44070954 0.44070954
  0.44071172 0.44071121 0.44071275 0.44071393 0.44071452 0.44071089
  0.44071124 0.44071322 0.44071468 0.44071337 0.4407114  0.44071163
  0.44071325 0.44071598 0.44071586 0.44071438 0.44071591 0.44071769
  0.44071752 0.44071663 0.44071844 0.44071837 0.44071957 0.44071773
  0.44071798 0.4407186  0.44071955 0.44071657 0.44068247 0.44068238]]
Shape of Y_hat: (1, 156)

================================================================================
                                From Back Propagation
================================================================================

Shape of A4 is (10, 156) and A4 values are:
[[0.45541162 0.45540516 0.45539981 ... 0.45539823 0.45551934 0.4554533
5]
 [0.47666289 0.47665391 0.47664168 ... 0.47655611 0.47665591 0.4766608
5]
 [0.40509038 0.40508935 0.40508653 ... 0.40506649 0.40503514 0.4050693
8]
 ...
 [0.52604846 0.52606348 0.52608607 ... 0.52627476 0.52612598 0.5260768
2]
 [0.53002817 0.53001653 0.52999875 ... 0.52986357 0.5299523  0.5300000
8]
 [0.52968604 0.52968787 0.52969104 ... 0.52974253 0.52970074 0.5296916
6]]


Shape of Z5 is (1, 156) and Z5 values are:
[[-0.23839179 -0.23837998 -0.23836422 -0.23834206 -0.23832868 -0.238314
34
  -0.2383016  -0.23830144 -0.23830148 -0.23830022 -0.23830044 -0.238392
03
  -0.2383912  -0.23838942 -0.23838814 -0.23837775 -0.23836295 -0.238348
83
  -0.23833413 -0.2383207  -0.23830873 -0.23829008 -0.23828973 -0.238289
07
  -0.23828873 -0.23828823 -0.23828785 -0.23827904 -0.23827079 -0.238264
07
  -0.2382588  -0.23825284 -0.23824864 -0.23827949 -0.238269   -0.238260
28
  -0.23825391 -0.23824944 -0.23824729 -0.23824744 -0.2382351  -0.238234
96
  -0.23823449 -0.23823571 -0.23823553 -0.23837932 -0.23837863 -0.238376
48
  -0.23836416 -0.2383646  -0.23836355 -0.23835222 -0.23834836 -0.238347
44
  -0.23833531 -0.23833383 -0.23833442 -0.23832354 -0.23832445 -0.238323
09
  -0.23831008 -0.23831012 -0.23831004 -0.23827976 -0.23828002 -0.238279
16
  -0.2382786  -0.23827102 -0.23827152 -0.23827179 -0.23827229 -0.238265
46
  -0.23825899 -0.23825953 -0.23825922 -0.23825922 -0.23825153 -0.238251
53
```

```
  -0.23825265 -0.23824452 -0.23824525 -0.23824499 -0.23824418 -0.238240
98
  -0.23824117 -0.23824117 -0.23824112 -0.2382425  -0.23838498 -0.238371
89
  -0.23835718 -0.23834594 -0.2383344  -0.23832232 -0.23830887 -0.238384
84
  -0.23836806 -0.23835602 -0.23834638 -0.23832119 -0.23830738 -0.238307
38
  -0.23838568 -0.23837066 -0.23835796 -0.23834583 -0.23832909 -0.238318
93
  -0.23832939 -0.2383177  -0.23831335 -0.23831813 -0.23837666 -0.238366
18
  -0.23835164 -0.23834032 -0.23832559 -0.23833572 -0.23832018 -0.238311
73
  -0.23830279 -0.23828451 -0.23828469 -0.23828436 -0.23828293 -0.238282
91
  -0.23827407 -0.23827615 -0.2382699  -0.23826513 -0.23826271 -0.238277
44
  -0.23827604 -0.238268   -0.23826209 -0.23826737 -0.23827536 -0.238274
46
  -0.23826788 -0.23825681 -0.2382573  -0.23826329 -0.23825709 -0.238249
85
  -0.23825053 -0.23825418 -0.23824682 -0.23824709 -0.23824222 -0.238249
7
  -0.23824869 -0.23824618 -0.2382423  -0.23825442 -0.23839274 -0.238393
12]]

Shape of Current Weights: (1, 10)
Shape of Current Bias:         (1, 1)
==========================================================================
=========================
                                 From Back Propagation
==========================================================================
=========================

Shape of A3 is (25, 156) and A3 values are:
[[0.37868092 0.37861164 0.37849934 ... 0.37758347 0.37802649 0.3784372
3]
 [0.33766359 0.3376166  0.33755401 ... 0.33725625 0.33763106 0.3376558
1]
 [0.38565245 0.38604453 0.38656302 ... 0.39023131 0.38539277 0.3855231
7]
 ...
 [0.50512662 0.50502523 0.5048896  ... 0.50399335 0.50510807 0.5051277
 ]
 [0.48088206 0.48065589 0.48030787 ... 0.47719023 0.47943774 0.4803468
 ]
 [0.43003401 0.43016414 0.43036369 ... 0.432042   0.43087166 0.4303445
6]]


Shape of Z4 is (10, 156) and Z4 values are:
[[-0.17882857 -0.17885463 -0.17887618 ... -0.17888256 -0.17839424
  -0.17866031]
 [-0.09341633 -0.09345233 -0.09350132 ... -0.09384437 -0.09344431
  -0.09342448]
 [-0.38429928 -0.38430356 -0.38431528 ... -0.3843984  -0.3845285
```

```
  -0.38438644]
 ...
 [ 0.10428827  0.10434852  0.10443911 ...  0.10519596  0.1045992
   0.10440202]
 [ 0.12025739  0.12021066  0.12013929 ...  0.11959664  0.11995282
   0.12014462]
 [ 0.11888397  0.11889135  0.11890406 ...  0.11911073  0.118943
   0.11890655]]

Shape of Current Weights: (10, 25)
Shape of Current Bias:         (10, 1)
==========================================================================
=========================
                                 From Back Propagation
==========================================================================
=========================

Shape of A2 is (25, 156) and A2 values are:
[[0.50353918 0.50564042 0.50849062 ... 0.52884334 0.5048451  0.5038686
8]
 [0.4094999  0.41184831 0.41517878 ... 0.44095157 0.41556533 0.4116280
7]
 [0.43495974 0.43395632 0.43280726 ... 0.42597681 0.44158525 0.4375712
1]
 ...
 [0.49842798 0.49723947 0.49564387 ... 0.48510998 0.49784071 0.4983004
5]
 [0.6012541  0.59799451 0.5933993  ... 0.55928962 0.59338375 0.5985130
7]
 [0.43852708 0.44036758 0.44305158 ... 0.46472039 0.44560817 0.4410826
6]]


Shape of Z3 is (25, 156) and Z3 values are:
[[-0.4951508  -0.4954453  -0.49592266 ... -0.49981787 -0.49793323
  -0.49618668]
 [-0.67372348 -0.67393359 -0.6742135  ... -0.67554539 -0.67386897
  -0.67375828]
 [-0.46562422 -0.46396966 -0.46178264 ... -0.44634004 -0.46672043
  -0.46616991]
 ...
 [ 0.02050721  0.02010158  0.01955902 ...  0.01597374  0.02043301
   0.02051151]
 [-0.07650905 -0.07741507 -0.07880928 ... -0.09130247 -0.08229547
  -0.07865332]
 [-0.28171241 -0.28118151 -0.28036746 ... -0.27352468 -0.27829571
  -0.2804455 ]]

Shape of Current Weights: (25, 25)
Shape of Current Bias:         (25, 1)
==========================================================================
=========================
                                 From Back Propagation
==========================================================================
=========================

Shape of A1 is (15, 156) and A1 values are:
```

```
[[0.4085473  0.39453742 0.37449261 ... 0.20965304 0.36958434 0.3948171
7]
 [0.47524776 0.48246041 0.48970765 ... 0.52587366 0.39055448 0.4424030
4]
 [0.33740588 0.32306102 0.30242773 ... 0.14468873 0.28577668 0.3185410
4]
 ...
 [0.37099819 0.35615712 0.3352915  ... 0.17345701 0.33677856 0.3591062
8]
 [0.43459895 0.410453   0.37699107 ... 0.14025237 0.3955069  0.4216566
6]
 [0.43175748 0.41852634 0.39880891 ... 0.22706506 0.3719678  0.4099591
6]]


Shape of Z2 is (25, 156) and Z2 values are:
[[ 0.01415696  0.02256265  0.03396575 ...  0.1155016   0.019381
   0.01547502]
 [-0.36603314 -0.35632978 -0.34259696 ... -0.23730105 -0.34100518
  -0.35723907]
 [-0.26164351 -0.26572735 -0.27040668 ... -0.2982849  -0.23473087
  -0.25102508]
 ...
 [-0.00628811 -0.01104223 -0.01742496 ... -0.05957771 -0.00863722
  -0.00679822]
 [ 0.41069329  0.39711582  0.37803592 ...  0.23827953  0.37797146
   0.39927338]
 [-0.24714198 -0.23967039 -0.22878644 ... -0.14135332 -0.2184317
  -0.23676932]]

Shape of Current Weights: (25, 15)
Shape of Current Bias:         (25, 1)
==========================================================================
========================
                                 From Back Propagation
==========================================================================
========================

Shape of A0 is (2, 156) and A0 values are:
[[1.05414747 1.03110599 1.03110599 1.05414747 1.03110599 1.86059908
  2.59792627 3.42741935 4.16474654 4.87903226 1.74539171 2.48271889
  3.24308756 4.04953917 4.69470046 4.90207373 4.94815668 4.97119816
  4.94815668 4.97119816 5.75460829 5.77764977 5.84677419 5.82373272
  5.84677419 6.35368664 7.06797235 7.92050691 8.72695853 9.39516129
  9.41820276 9.44124424 9.48732719 9.51036866 9.53341014 6.46889401
  7.25230415 7.87442396 8.61175115 9.11866359 1.74539171 1.67626728
  1.67626728 2.34447005 2.36751152 2.34447005 3.08179724 3.91129032
  3.05875576 3.12788018 4.00345622 3.95737327 6.35368664 6.35368664
  6.35368664 7.04493088 6.97580645 6.97580645 6.9297235  7.59792627
  7.57488479 7.55184332 7.59792627 8.12788018 8.15092166 8.19700461
  8.19700461 8.75       8.75       8.70391705 8.70391705 9.16474654
  9.07258065 1.37672811 1.37672811 1.37672811 1.37672811 1.37672811
  2.09101382 2.04493088 2.0218894  2.0218894  1.99884793 2.73617512
  2.71313364 2.71313364 2.69009217 3.54262673 3.49654378 3.49654378
  3.49654378 3.49654378 3.12788018 4.57949309 4.32603687 3.9343318
  4.34907834 4.39516129 4.39516129 4.39516129 3.8421659  3.05875576
  2.36751152 3.22004608 3.68087558 4.07258065 6.67626728 6.10023041
```

```
  6.05414747 6.12327189 6.12327189 6.63018433 6.65322581 6.65322581
  7.22926267 7.41359447 8.26612903 7.85138249 8.72695853 7.89746544
  7.89746544 7.89746544 7.18317972 7.22926267 8.42741935 8.45046083
  9.14170507 9.09562212 9.09562212 8.24308756 7.55184332 6.8375576
  8.42741935 7.22926267 7.87442396 4.64861751 4.60253456 4.62557604
  4.57949309 3.08179724 2.69009217 2.34447005 2.73617512 2.80529954
  3.72695853 4.39516129 4.18778802 3.8421659  2.75921659 2.43663594
  2.0218894  1.33064516 1.67626728 1.37672811 2.09101382 1.44585253]
 [1.05702765 1.51324885 2.13536866 3.04781106 3.62845622 4.29205069
  4.93490783 4.95564516 4.95564516 5.01785714 4.97638249 1.015553
  1.015553   1.03629032 1.03629032 1.43029954 2.03168203 2.63306452
  3.29665899 3.93951613 4.52016129 5.5985023  5.61923963 5.66071429
  5.68145161 5.70218894 5.70218894 6.2828341  6.90495392 7.48559908
  8.00403226 8.6468894  9.14458525 6.15841014 7.02937788 7.77592166
  8.4187788  8.93721198 9.24827189 9.26900922 9.26900922 9.26900922
  9.31048387 9.3312212  9.35195853 1.51324885 1.51324885 1.5547235
  2.09389401 2.07315668 2.07315668 2.55011521 2.52937788 2.57085253
  3.13076037 3.13076037 3.11002304 3.64919355 3.60771889 3.60771889
  4.31278802 4.31278802 4.31278802 6.22062212 6.19988479 6.26209677
  6.30357143 6.88421659 6.84274194 6.82200461 6.78052995 7.36117512
  7.98329493 7.34043779 7.36117512 7.36117512 7.90034562 7.90034562
  7.90034562 8.52246544 8.46025346 8.48099078 8.54320276 8.93721198
  8.91647465 8.91647465 8.91647465 8.95794931 1.24366359 1.76209677
  2.36347926 2.84043779 3.35887097 3.87730415 4.56163594 1.22292627
  1.86578341 2.36347926 2.77822581 3.93951613 4.64458525 4.64458525
  1.26440092 1.82430876 2.32200461 2.81970046 3.40034562 3.96025346
  3.44182028 4.02246544 4.25057604 3.96025346 1.28513825 1.72062212
  2.28052995 2.77822581 3.40034562 2.94412442 3.62845622 4.18836406
  4.70679724 5.88882488 5.90956221 5.93029954 5.97177419 5.97177419
  6.61463134 6.44873272 6.9671659  7.40264977 7.61002304 6.42799539
  6.49020737 7.15380184 7.67223502 7.09158986 6.53168203 6.59389401
  7.05011521 7.71370968 7.63076037 7.17453917 7.6514977  8.21140553
  8.29435484 8.08698157 8.68836406 8.60541475 8.83352535 8.16993088
  8.1906682  8.29435484 8.6468894  7.69297235 1.         1.        ]]


Shape of Z1 is (15, 156) and Z1 values are:
[[-0.36997403 -0.42827878 -0.51299107 ... -1.32701805 -0.53400041
  -0.42710782]
 [-0.09908998 -0.07018716 -0.04117523 ...  0.10358716 -0.4449821
  -0.23141509]
 [-0.67487602 -0.73973993 -0.8357638  ... -1.77688071 -0.91598504
  -0.76048473]
 ...
 [-0.52793696 -0.59208274 -0.68434832 ... -1.56132217 -0.6776833
  -0.57924524]
 [-0.26311163 -0.36209303 -0.50233936 ... -1.81319542 -0.42422204
  -0.31597633]
 [-0.27468427 -0.32882586 -0.41043046 ... -1.22495828 -0.52378416
  -0.36413419]]

Shape of Current Weights: (15, 2)
Shape of Current Bias:         (15, 1)
======================================================================
========================

                                Prediction Vector is:
```

```
[[0.44068271 0.44068562 0.4406895  0.44069496 0.44069826 0.4407018
  0.44070494 0.44070498 0.44070497 0.44070528 0.44070522 0.44068265
  0.44068285 0.44068329 0.44068361 0.44068617 0.44068982 0.4406933
  0.44069692 0.44070023 0.44070318 0.44070778 0.44070786 0.44070803
  0.44070811 0.44070823 0.44070833 0.4407105  0.44071253 0.44071419
  0.44071549 0.44071696 0.44071799 0.44071039 0.44071297 0.44071512
  0.44071669 0.44071779 0.44071832 0.44071829 0.44072133 0.44072136
  0.44072148 0.44072118 0.44072122 0.44068578 0.44068595 0.44068648
  0.44068952 0.44068941 0.44068967 0.44069246 0.44069341 0.44069364
  0.44069663 0.44069699 0.44069685 0.44069953 0.44069931 0.44069964
  0.44070285 0.44070284 0.44070286 0.44071032 0.44071026 0.44071047
  0.44071061 0.44071247 0.44071235 0.44071229 0.44071216 0.44071385
  0.44071544 0.44071531 0.44071538 0.44071538 0.44071728 0.44071728
  0.440717   0.44071901 0.44071883 0.44071889 0.44071909 0.44071988
  0.44071983 0.44071983 0.44071984 0.44071951 0.44068438 0.44068761
  0.44069124 0.44069401 0.44069685 0.44069983 0.44070315 0.44068442
  0.44068856 0.44069152 0.4406939  0.44070011 0.44070351 0.44070351
  0.44068421 0.44068791 0.44069104 0.44069403 0.44069816 0.44070066
  0.44069809 0.44070097 0.44070204 0.44070086 0.44068644 0.44068902
  0.4406926  0.44069539 0.44069902 0.44069653 0.44070036 0.44070244
  0.44070464 0.44070915 0.4407091  0.44070919 0.44070954 0.44070954
  0.44071172 0.44071121 0.44071275 0.44071393 0.44071452 0.44071089
  0.44071124 0.44071322 0.44071468 0.44071337 0.4407114  0.44071163
  0.44071325 0.44071598 0.44071586 0.44071438 0.44071591 0.44071769
  0.44071752 0.44071663 0.44071844 0.44071837 0.44071957 0.44071773
  0.44071798 0.4407186  0.44071955 0.44071657 0.44068247 0.44068238]]

==========================================================================
=========================
```

Updated Parameters are:

```
==========================================================================
=========================
Weight1
[[-0.22755099 -0.20267532]
 [-0.39980981 -0.04343325]
 [-0.277668   -0.19579037]
 [-0.1356519  -0.30403155]
 [-0.24607814 -0.23907548]
 [-0.11211506  0.07307536]
 [-0.17198645 -0.28549016]
 [-0.14454986 -0.25910724]
 [-0.22601882 -0.11666415]
 [-0.25557881 -0.19396177]
 [-0.25428054 -0.19613937]
 [-0.16234123 -0.28535235]
 [-0.20887042 -0.20737921]
 [-0.21984983 -0.27667379]
 [-0.29857884 -0.1906411 ]]
==========================================================================
=========================
```

Updated Parameters are:

```
==========================================================================
=========================
bias1
[[-0.06542243]
 [ 0.18377498]
 [-0.26688506]
```

```
 [-0.02571052]
 [ 0.00632012]
 [ 0.1024791 ]
 [ 0.01439965]
 [-0.12410231]
 [-0.04487825]
 [ 0.01622643]
 [-0.06686533]
 [ 0.0392533 ]
 [-0.22307342]
 [ 0.14008655]
 [ 0.11225584]]
==========================================================================
=========================
```

Updated Parameters are:

```
==========================================================================
=========================
Weight2
[[-4.88115938e-02  4.23570851e-02 -2.38680144e-03 -9.73716825e-02
  -1.59597062e-03  6.17895748e-02 -5.15096213e-02 -5.41164659e-02
  -3.24435461e-02  2.84541350e-02  1.14825435e-01 -7.84697127e-02
   3.74159289e-02  9.91157441e-03 -1.98438520e-01]
 [-5.70201231e-02 -3.18273722e-02 -1.10554502e-02  1.82967902e-02
  -2.14281084e-01 -3.32794543e-02 -8.10223103e-02 -1.60325542e-01
   2.76654497e-02  5.87859214e-02 -7.82005407e-02  6.94029856e-02
  -5.14369263e-02 -4.91808433e-03 -1.22315291e-01]
 [ 1.43242032e-01 -2.84650392e-01 -1.62986512e-02  5.50838836e-02
  -2.13679817e-01 -5.70465612e-02 -2.10909286e-02  6.59536085e-02
   9.98983488e-02 -5.52450910e-02 -1.51427815e-01  1.21754269e-01
   1.08397193e-01 -5.78666151e-02  2.25525363e-02]
 [ 2.29132589e-02  3.78057385e-02  1.32228039e-02  1.26188035e-01
  -1.84182098e-01  6.57503474e-02  2.46242918e-02 -3.82919316e-02
   9.23038171e-02 -2.49285421e-01  1.03113902e-01  2.35806324e-02
  -1.26762455e-01  3.15889006e-02 -4.30117423e-02]
 [ 2.43231949e-01  1.64686619e-01  3.68632792e-02 -8.64310551e-02
  -6.87413008e-02 -7.08868904e-02 -6.94676263e-02 -1.06831344e-01
  -8.41849465e-02 -4.25657266e-02 -6.47457554e-02 -8.49108270e-02
  -1.06359602e-01  2.43306897e-01 -1.59937299e-01]
 [-1.17421669e-01  2.44096350e-02 -3.95526351e-02  2.78972914e-02
   6.95331775e-02  8.79231404e-02  6.17712168e-02 -1.15962139e-01
   8.58524159e-02 -1.91422711e-01 -2.44841628e-02 -6.48489004e-02
  -1.19534480e-01  4.74471467e-02 -3.09305185e-02]
 [ 8.67586576e-02 -1.66983755e-01  7.74584054e-02  3.53500447e-02
   2.29517018e-03 -1.79984953e-01 -3.85649442e-02 -1.71198496e-01
  -2.33203805e-01  3.13096011e-01  8.40881386e-02  1.64272316e-01
  -5.63106995e-02  5.79314482e-02  5.71792795e-02]
 [ 4.48604736e-02 -1.84743541e-02 -3.00291204e-02 -2.21460447e-01
   5.06175230e-02  3.98301730e-03  9.83499431e-02 -4.40229647e-02
   1.49104866e-01 -5.96920355e-02 -1.38595376e-01  7.87711089e-02
  -6.02994358e-02 -1.37205170e-01 -1.33805028e-04]
 [ 6.06098163e-02  5.59196721e-03  4.26458759e-02  3.96607916e-01
   7.18793798e-02  1.15305922e-01 -2.11803577e-01  2.01792997e-02
   5.27094226e-02 -5.11462227e-02 -1.00438808e-01  2.48538173e-02
  -4.47054812e-02 -7.09206118e-02  1.02535372e-01]
 [ 1.18293881e-01  1.14564510e-02 -5.26156286e-02  3.69637386e-02
   7.25667889e-02  2.47515269e-02 -1.58751210e-01 -5.03701866e-02
   1.08802748e-02  4.73077140e-02  8.30494119e-02  6.08189023e-02
```

```
 -1.26871780e-01 -8.24549238e-02 -1.34736417e-01]
[ 1.65308490e-01 -6.24283421e-04  4.81782743e-02  8.89472417e-02
 -4.31967579e-02 -1.53174453e-01 -5.59578762e-02 -3.12492696e-02
  1.25293180e-01  7.21658855e-02 -1.21632767e-01  5.15261882e-02
  6.01576670e-02 -1.17755062e-01 -2.33446405e-02]
[-2.00319594e-01  1.42207805e-02 -3.87630118e-02 -1.49485020e-01
 -8.02008684e-02 -1.43465106e-02 -6.87195477e-02  1.33669483e-02
  3.02043515e-02 -9.89740344e-02 -4.42679215e-02  1.99436885e-01
 -1.34314452e-03 -9.64014059e-02 -6.55716529e-03]
[-1.49149664e-01  9.44319389e-02  2.98293519e-02  9.40849826e-02
  7.98245029e-02  6.68740718e-04  8.41156215e-02  2.56018748e-03
 -9.12981005e-02 -1.17293036e-01 -5.78691103e-02 -2.65588114e-01
  1.69135419e-01 -1.83135791e-01 -2.02785957e-02]
[-1.47012365e-01 -2.21349210e-01 -1.54060376e-02 -4.49358000e-02
 -2.63403963e-02  1.65947778e-02 -7.52458474e-02  2.13135981e-02
  2.62982963e-02 -4.83896605e-02 -4.13712034e-02  3.88294891e-02
 -7.70848302e-03  4.20623322e-03 -2.50021001e-01]
[-9.38580282e-03  1.88818651e-02 -2.07243168e-02  1.91420937e-02
  1.80079400e-01 -2.97019502e-02  5.31422737e-02 -1.01541764e-01
 -1.10225832e-01 -6.28877084e-02 -1.14970906e-01 -1.57528882e-02
 -1.06800821e-01 -2.91897377e-02 -1.56284265e-01]
[-1.80304792e-01 -8.61481335e-02 -1.13804936e-01 -7.95970738e-02
 -7.14582442e-02 -7.30049026e-02  9.12927582e-02  1.20522229e-01
  4.77848097e-02 -5.06856245e-02  1.36822463e-01 -1.67953331e-01
 -2.15619050e-01  1.52294981e-02 -1.26592635e-02]
[-2.91119925e-02 -1.54540840e-02 -1.71201217e-01 -1.30062312e-01
  1.13088322e-01  6.46987661e-02 -8.55260949e-02  1.76833617e-01
 -1.31991010e-01 -7.19731076e-02  1.62858996e-02 -1.34435116e-01
 -6.21615548e-02 -2.89484699e-02 -5.20562171e-02]
[ 7.19334613e-02  4.06011533e-02 -1.17059424e-01 -8.25094260e-02
  7.71484526e-03 -4.47248860e-02 -9.20807014e-02  2.60322188e-02
  5.71294201e-02 -7.79162461e-02  6.59755557e-02 -1.77066479e-01
 -1.74389431e-01  3.83802771e-02 -9.59480434e-02]
[-1.14876354e-01 -4.50647413e-02 -7.48883807e-02  1.83218714e-02
 -1.55854160e-01 -7.53037461e-02  3.02763161e-01 -5.47871722e-03
 -2.16269842e-01  4.51472059e-02  4.19802157e-02  1.23449463e-01
  1.46917132e-03 -7.69957232e-02  1.28357118e-01]
[ 5.59297412e-02 -1.98897784e-01  6.75645773e-02 -3.77718007e-02
  1.00680464e-01 -7.56724743e-02  6.51919450e-02  2.83499977e-03
  3.35630268e-02 -1.69662333e-02 -5.44802318e-02 -8.29687016e-03
  4.97286469e-02  3.00410424e-02  1.48914610e-01]
[ 2.74182278e-02  4.48793846e-02  2.03089614e-01 -7.75270235e-03
  4.32613688e-02 -9.84063245e-02 -9.11574695e-03  1.47745776e-01
  6.30924131e-03  1.30322470e-01 -1.19415695e-01 -1.54988714e-01
  1.74185649e-02 -1.48583060e-01  2.54545317e-01]
[ 1.09614988e-01 -1.43351180e-01 -2.38939138e-02 -7.20972213e-02
  3.12476618e-02 -4.40404165e-02  7.98078499e-02  1.30303672e-01
 -4.71222294e-02 -1.32198673e-01  4.32659028e-02 -3.14324532e-02
  1.01075346e-01 -2.68952366e-02  7.04114192e-02]
[ 1.83272656e-02 -3.77338619e-02 -5.21311820e-02  5.68667595e-02
  2.42585755e-01  4.54193905e-02 -2.65945890e-02  5.41745013e-02
 -1.36545049e-02 -1.43020161e-01  1.79421079e-02  1.39797294e-01
 -4.50368647e-02 -1.24312645e-01  3.62431071e-02]
[ 1.68480524e-01  7.59692717e-02  9.49781206e-02  2.16378638e-01
  1.52172419e-01  3.42331812e-02 -3.37121472e-02 -2.11050843e-03
 -3.44053446e-02  7.05556767e-02 -1.00785056e-01  1.40159273e-01
  1.71689178e-03 -5.12217030e-02  6.94645958e-02]
```

```
 [-2.22747070e-01 -1.02236393e-01 -7.29522072e-02  6.75917306e-02
  -5.92819118e-02  1.04207377e-01 -5.80906284e-02  3.55485672e-02
  -9.58437144e-02  1.00648071e-01 -3.84719495e-02  3.68832419e-02
  -6.27319821e-02 -1.20354652e-01 -3.56726287e-02]]
==========================================================================
==========================
```

Updated Parameters are:

```
==========================================================================
==========================
bias2
[[ 0.05999027]
 [-0.15112209]
 [-0.20253909]
 [-0.08071529]
 [ 0.02810024]
 [-0.15549114]
 [-0.10400817]
 [-0.03152781]
 [-0.08240602]
 [-0.02116982]
 [ 0.06936034]
 [-0.04779211]
 [-0.05648127]
 [ 0.02674657]
 [-0.05594895]
 [-0.14459693]
 [-0.15106288]
 [-0.16102056]
 [ 0.14158821]
 [-0.05444283]
 [ 0.00807848]
 [ 0.02196695]
 [-0.14382386]
 [ 0.01461647]
 [-0.10629403]]
==========================================================================
==========================
```

Updated Parameters are:

```
==========================================================================
==========================
Weight3
[[-0.23407024 -0.04267368 -0.1294445  -0.05843654  0.01017132  0.205318
29
  -0.0716322  -0.04073158  0.01076193 -0.00617553 -0.04164491 -0.131270
67
  -0.11878797 -0.04127861 -0.13832298 -0.08687667 -0.14698476  0.090921
31
  -0.17546134  0.16594655 -0.08369314 -0.13058988 -0.14249476  0.049908
98
   0.07999643]
 [-0.10906254  0.01290166 -0.03595416 -0.04781945 -0.00798608  0.054563
29
  -0.21276537 -0.24601782 -0.00459334 -0.0308431   0.04378671 -0.192737
51
  -0.12078199  0.13240641 -0.15240215  0.01615675 -0.100382   -0.061124
25
  -0.16234439  0.09539622 -0.21493049 -0.1438293  -0.11418091  0.090813
```

```
78
   0.00823831]
 [ 0.04241703 -0.02311993  0.00147294  0.02455073  0.13026799  0.001550
13
  -0.16912163  0.09016319 -0.01707164 -0.13578671 -0.04365276 -0.121453
85
   0.18534133 -0.05760446 -0.22274523  0.00903932 -0.10501825  0.107162
03
  -0.01240658 -0.2023241  -0.07595465 -0.13413095 -0.10021331 -0.092653
28
  -0.22373976]
 [-0.00578156 -0.1088582  -0.1114049   0.05043619  0.16543055 -0.085951
19
   0.15905176 -0.23007549  0.02974844 -0.08315031 -0.0333215  -0.121735
39
  -0.08270613 -0.05453117 -0.05714169  0.019945    0.21069629 -0.085033
34
  -0.04123802 -0.19929657 -0.27773097  0.11390132 -0.15726588 -0.102727
06
  -0.02064418]
 [ 0.06586542  0.01041177  0.16473297 -0.04282796 -0.20691616 -0.008982
86
  -0.01005478 -0.10616462 -0.05959904 -0.08340478  0.14771345 -0.084195
56
  -0.16241182  0.00505944 -0.20450964  0.02165447  0.01891335 -0.105903
97
  -0.08159587 -0.08424732  0.13589622  0.01445897 -0.14454055 -0.152717
12
  -0.03036166]
 [-0.02701726 -0.09834055  0.00685207 -0.04474577  0.08315976  0.020445
43
  -0.03170397 -0.01114647 -0.11505441  0.06327038  0.01214023 -0.065040
65
  -0.01170905 -0.0769853   0.2260187  -0.06657297  0.02969581  0.014578
28
  -0.10590114 -0.02404961 -0.05812229 -0.00052181  0.00105388  0.048328
23
   0.05527755]
 [-0.06596666 -0.07363402 -0.08089735 -0.11086376 -0.19840922  0.037457
71
  -0.02999013 -0.04543437 -0.19214237 -0.17490274 -0.27731538 -0.033247
71
   0.04382396  0.03651512 -0.03012792 -0.12895007 -0.0227134  -0.021266
4
   0.04492748  0.05235986 -0.05224784 -0.02853767  0.04542877  0.017713
71
  -0.03970808]
 [-0.24325826 -0.08861823  0.06097514 -0.01072987  0.07011218 -0.058465
17
  -0.0149858   0.0539543   0.04124049  0.01325901  0.08196626  0.109544
84
   0.11489539 -0.18912242 -0.07195687 -0.0548845  -0.05926128 -0.186232
82
   0.10331621 -0.12543863 -0.01681503 -0.26661153 -0.07597691 -0.055050
55
  -0.11724639]
 [ 0.04714187  0.21594477 -0.11045539 -0.11223522  0.14997396  0.032260
```

```
3
  -0.05462311 -0.153356    0.04572331 -0.00459499  0.1283316  -0.111084
73
  -0.04149824 -0.05475266 -0.04501166  0.08373252  0.06143386 -0.086516
13
  -0.03602973 -0.04839009  0.06214739 -0.04381448 -0.13706621 -0.063774
81
  -0.02844066]
 [ 0.06536695  0.10551526  0.10621895  0.01074046 -0.07695905  0.034224
63
  -0.04206668 -0.08788286  0.00143175  0.01416298  0.05948025 -0.114438
01
  -0.19146562  0.02599815 -0.12042346  0.07702058 -0.13360069 -0.081446
09
  -0.20857695  0.17839987 -0.07379899 -0.03574176 -0.07924088 -0.054643
12
   0.05774374]
 [-0.01677537 -0.02431367  0.09506826 -0.16197202  0.08691801  0.134481
85
  -0.1629832   0.00067201 -0.15725281 -0.23810707 -0.11281701  0.027286
43
   0.05046609 -0.06187689 -0.11106512 -0.06708112 -0.09566309 -0.086702
51
  -0.26880493 -0.0502524  -0.039653    0.19085297  0.04125183 -0.044392
16
  -0.01762968]
 [ 0.00500326 -0.09385349 -0.23276632 -0.10030397 -0.04948226 -0.014071
29
  -0.09648608 -0.11943208 -0.05573269 -0.02235291  0.02837428 -0.050103
66
   0.01778801 -0.12573516  0.05612884 -0.0296289  -0.16102694 -0.049656
44
  -0.01794436 -0.13351231  0.04400002 -0.06124791  0.01846323 -0.130420
28
   0.00562358]
 [ 0.0442121  -0.0682484  -0.04420159 -0.0848518   0.00611049 -0.022788
88
   0.02500802 -0.03327222 -0.15659823 -0.15909091 -0.07374071  0.020183
75
   0.20027711  0.06107896 -0.08650515 -0.22647658  0.02679199 -0.022526
87
  -0.14979805  0.06241474 -0.02768083 -0.06906285 -0.22014383  0.065841
1
  -0.01842103]
 [-0.0530024  -0.11999687 -0.06128014  0.0964689   0.0255135   0.175038
94
   0.0818231   0.0078745   0.06089081 -0.01102415 -0.17319061 -0.085674
51
   0.00799072 -0.1186033  -0.07634269 -0.14795188  0.14495101 -0.155591
01
  -0.13208681 -0.1152098   0.06934239  0.08545934 -0.08178457  0.027263
62
  -0.11399936]
 [-0.02707956  0.23833853  0.07076435 -0.03072145 -0.1585695  -0.054667
47
  -0.15583491 -0.24461733  0.03248642  0.03179676 -0.00744638  0.075438
39
```

```
  -0.19182125  0.11533377 -0.13212756  0.01546974  0.02241433  0.085034
18
   0.17289649  0.00931285 -0.06496542 -0.13744024  0.00060644 -0.114001
21
  -0.15943158]
 [-0.04664391  0.04504332 -0.05386045 -0.13100831 -0.01100603 -0.148318
68
  -0.17481585  0.120535   -0.00321124  0.1721505  -0.17434078  0.079737
68
  -0.04179195  0.24403987 -0.04483685 -0.06644411  0.01961251 -0.003544
93
  -0.0726702   0.0659049   0.04229479  0.06241944  0.01481087 -0.100163
  -0.09365595]
 [ 0.03292732 -0.11598708  0.14693165 -0.02243762 -0.10459955  0.079837
26
  -0.02500851  0.09434413 -0.00633303  0.15094618 -0.06523921 -0.242382
78
  -0.17573784 -0.18732356  0.03568453  0.15890592 -0.04228371 -0.155887
15
   0.04152309  0.02008851 -0.06485241  0.01463293 -0.02460184 -0.144233
37
   0.04492292]
 [-0.07662444 -0.11685836 -0.04631557  0.1313277   0.17126827  0.116299
06
  -0.07229958 -0.12787677  0.00710517 -0.04186789 -0.01276834 -0.136799
25
  -0.11253283 -0.13131335  0.05416752  0.08441398 -0.09084532  0.036002
88
   0.03760804 -0.09906705 -0.02553133  0.05539738 -0.1265023   0.095648
12
  -0.0440515 ]
 [-0.01933347 -0.04558804 -0.17010128  0.00928375 -0.02481392 -0.063932
05
  -0.04403016  0.01741435 -0.04112019 -0.07783244 -0.01773774  0.052455
54
  -0.01951535 -0.10254256  0.06076234 -0.050725    0.03671226 -0.036107
35
  -0.12008645 -0.15174646 -0.11568354 -0.04849202 -0.2494678   0.010285
96
   0.0873143 ]
 [-0.05034209 -0.13282225 -0.18936194 -0.00291974  0.01624973 -0.017936
42
   0.04685614 -0.09238098 -0.05252061  0.00192902 -0.0492522   0.024980
82
   0.02566777 -0.0508868  -0.11948024 -0.09423768  0.08698988 -0.142656
91
  -0.02055052 -0.12468517  0.20421509 -0.08937824  0.03835616 -0.125805
25
   0.29577497]
 [-0.15816304  0.01510256 -0.14659871  0.05801058 -0.14901568 -0.066607
25
  -0.18091426 -0.06338537 -0.02555692  0.15002964 -0.25534211  0.032194
45
  -0.01824696 -0.08315153 -0.04289891  0.01859569 -0.02494454 -0.025294
27
  -0.10297833 -0.06363979  0.02350225 -0.11659971 -0.07539995 -0.019867
6
```

```
   0.01060534]
 [ 0.0123772  -0.04215667 -0.22618707  0.05060822  0.07510846  0.095666
8
   0.0110888   0.05910974 -0.05706964 -0.13716674 -0.04426827 -0.048799
46
   0.0751848   0.05549649 -0.07543988 -0.06478649 -0.02793857 -0.016025
49
   0.11383686 -0.07528743  0.10064359 -0.166197   -0.09441991  0.135747
1
   0.01381636]
 [-0.01813183  0.03482995 -0.04627967 -0.02212975 -0.00545822 -0.004101
81
   0.01073617 -0.08509415  0.00633249 -0.09883971  0.02916074 -0.042737
23
  -0.00147849  0.00166053 -0.09911511 -0.07734954 -0.03915272  0.020068
53
   0.06462979 -0.03265975 -0.09656912 -0.00429483 -0.02938986  0.043748
69
   0.0942623 ]
 [ 0.16517042 -0.18814218 -0.072195   -0.03532139  0.05015941  0.041021
51
  -0.01941957  0.04876247 -0.084411   -0.06436309  0.00085284 -0.132055
18
   0.12973324 -0.10475304 -0.13770658  0.00764047 -0.21487593 -0.067200
91
  -0.04532692  0.10004858  0.27417857 -0.01102438 -0.15509331 -0.005140
71
   0.04063446]
 [-0.11936594  0.01070339  0.13250998  0.02161207 -0.10442811 -0.080618
69
  -0.18719329 -0.06989523 -0.08635857  0.11066958 -0.18199349 -0.181809
02
  -0.00652568  0.03333488 -0.07924489 -0.00434384  0.04201078  0.049389
28
   0.00823529  0.0269781  -0.18171039  0.05184515 -0.01281129 -0.112722
06
  -0.06422309]]
==========================================================================
========================
                          Updated Parameters are:
==========================================================================
==========================
bias3
[[-0.07838111]
 [-0.10161939]
 [-0.06616435]
 [-0.08837373]
 [-0.19367006]
 [ 0.16354261]
 [-0.01156939]
 [ 0.16829909]
 [-0.07915205]
 [ 0.1086945 ]
 [-0.0630346 ]
 [ 0.10513883]
 [ 0.0404267 ]
 [ 0.02414327]
```

```
 [-0.06903908]
 [-0.02960827]
 [ 0.08130009]
 [-0.24940741]
 [-0.11755423]
 [-0.17501587]
 [-0.13901756]
 [ 0.01048012]
 [ 0.03204225]
 [-0.07081423]
 [ 0.06185239]]
==========================================================================
=========================
```

Updated Parameters are:

```
==========================================================================
=========================
Weight4
[[-0.09407775 -0.07810364 -0.00868581  0.01925951 -0.03336323 -0.136160
06
   0.03620422  0.14457909 -0.06324068 -0.0239539  -0.13152397 -0.022053
41
  -0.11437423 -0.00797887  0.13075452  0.02578435 -0.0983174   0.057432
79
  -0.19184124  0.09771853  0.01140992 -0.1334062  -0.05909558 -0.115976
51
   0.17561548]
 [ 0.03632372 -0.11880537 -0.08802368 -0.0052356  -0.0774626  -0.006724
6
   0.0169475  -0.16991058  0.03458507  0.13962303  0.01011237  0.039565
77
  -0.07514456 -0.07653106  0.00573378 -0.11477861 -0.1874983   0.058716
48
  -0.085363   -0.00198413 -0.00822085  0.01238844  0.03197416  0.026206
75
  -0.0529372 ]
 [ 0.06066801 -0.05431987  0.01431512 -0.08268403 -0.01223279 -0.114417
68
   0.11788281  0.00728108 -0.09890831 -0.20491464 -0.09352049  0.107725
21
  -0.08779095  0.07187264 -0.04610238 -0.06012835 -0.13181931  0.004485
58
   0.08122439  0.05339517  0.03182793 -0.13214276 -0.01866909 -0.140813
92
  -0.10973032]
 [ 0.01464591 -0.12623868  0.02520469 -0.05429185  0.12001722 -0.048240
24
   0.02491135  0.07110045  0.02776906  0.03242005 -0.19827603  0.061858
67
  -0.18943975 -0.09841786 -0.27370515 -0.06628124 -0.09977775 -0.053838
28
  -0.12520711 -0.04683242 -0.09875822 -0.05391769  0.04779718 -0.249305
54
  -0.03559319]
 [-0.04434201 -0.18118522 -0.07308761  0.11209885  0.00720646 -0.094585
39
   0.04391251  0.00205764 -0.16253028 -0.0717595  -0.03392142 -0.028838
29
```

```
   0.00238173 -0.03281664 -0.02734606 -0.08784905 -0.07122023 -0.082844
65
   0.02234278 -0.04253978 -0.08497626  0.03954015  0.20729243 -0.046988
93
   0.09611979]
 [-0.07978242 -0.00246432  0.06482525  0.08689409  0.18830401 -0.080314
42
  -0.01430761  0.10860177  0.10255769 -0.11205958 -0.02191872  0.078627
64
   0.0989726  -0.11933173  0.012063   -0.24769983  0.07551039  0.153297
14
  -0.1289799  -0.04415903 -0.15972002 -0.07284358  0.02799201  0.033586
87
   0.01789916]
 [-0.15857758 -0.1017983   0.16627894  0.00310598 -0.06204708 -0.003753
14
  -0.0775484  -0.00787999 -0.10161417 -0.09326768 -0.17675069  0.153954
63
   0.04910038  0.03775573  0.06355271 -0.03836352 -0.13376096  0.028843
84
   0.04937319  0.03151961 -0.05716278 -0.17769098  0.05311279  0.016309
02
  -0.02829013]
 [-0.04275548 -0.03016047 -0.07596196 -0.16663557 -0.02984052 -0.071693
01
   0.0126165  -0.05491497  0.0035605  -0.14596616  0.02505541  0.185832
95
  -0.03226023  0.03858066  0.06453466  0.00994971 -0.00109798 -0.177689
79
  -0.10075685  0.13247987  0.00268468 -0.00530893  0.16820114 -0.195324
64
   0.08312058]
 [ 0.04592824 -0.21146652 -0.082855    0.02307936 -0.0891521  -0.104699
8
   0.04154804 -0.04253211 -0.00568824 -0.04148583 -0.0064542   0.009725
23
   0.19869502  0.01645785 -0.0927824   0.01282349  0.00082997  0.308816
98
  -0.16120355  0.04755122  0.00838112  0.12670312 -0.12761259 -0.147332
22
   0.01322562]
 [ 0.06458443  0.02692318  0.04357835 -0.0239683   0.08128427 -0.015514
19
  -0.06948364  0.12292433 -0.11097805 -0.18567213 -0.05945659 -0.034446
32
  -0.02880528 -0.05413807  0.01460253 -0.05945427 -0.11217717  0.117798
9
  -0.03669146  0.08743003 -0.00046007  0.02202258  0.12834167 -0.209950
42
   0.09042579]]
==========================================================================
=========================
                        Updated Parameters are:
==========================================================================
=========================
bias4
[[-0.04310091]
```

```
 [ 0.03751119]
 [-0.09339319]
 [-0.04640459]
 [-0.06490095]
 [-0.15981835]
 [-0.05600278]
 [ 0.13156289]
 [ 0.07795976]
 [ 0.09109806]]
==========================================================================
========================
                          Updated Parameters are:
==========================================================================
========================
Weight5
[[-0.04582835 -0.04186661 -0.06484845 -0.2245137  -0.04713479 -0.099664
96
   0.06379172  0.06624243  0.01671737 -0.11613209]]
==========================================================================
========================
                          Updated Parameters are:
==========================================================================
========================
bias5
[[-0.10855453]]

==================================End of Output=========================
======================================
```

After running, these are the Weights and Bias values for each Layer in our Neural Network

They have been printed above. Here, they are printed again for better visuals

In [463]:
```
for i in parameters :
    print("\033[1m"+"\n",i,"\033[0m"+"\n", parameters[i])
```

Weight1

```
[[-0.22755099 -0.20267532]
[-0.39980981 -0.04343325]
[-0.277668   -0.19579037]
[-0.1356519  -0.30403155]
[-0.24607814 -0.23907548]
[-0.11211506  0.07307536]
[-0.17198645 -0.28549016]
[-0.14454986 -0.25910724]
[-0.22601882 -0.11666415]
[-0.25557881 -0.19396177]
[-0.25428054 -0.19613937]
[-0.16234123 -0.28535235]
[-0.20887042 -0.20737921]
[-0.21984983 -0.27667379]
[-0.29857884 -0.1906411 ]]
```

bias1

```
[[-0.06542243]
[ 0.18377498]
[-0.26688506]
[-0.02571052]
[ 0.00632012]
[ 0.1024791 ]
[ 0.01439965]
[-0.12410231]
[-0.04487825]
[ 0.01622643]
[-0.06686533]
[ 0.0392533 ]
[-0.22307342]
[ 0.14008655]
[ 0.11225584]]
```

Weight2

```
[[-4.88115938e-02  4.23570851e-02 -2.38680144e-03 -9.73716825e-02
 -1.59597062e-03  6.17895748e-02 -5.15096213e-02 -5.41164659e-02
 -3.24435461e-02  2.84541350e-02  1.14825435e-01 -7.84697127e-02
  3.74159289e-02  9.91157441e-03 -1.98438520e-01]
[-5.70201231e-02 -3.18273722e-02 -1.10554502e-02  1.82967902e-02
 -2.14281084e-01 -3.32794543e-02 -8.10223103e-02 -1.60325542e-01
  2.76654497e-02  5.87859214e-02 -7.82005407e-02  6.94029856e-02
 -5.14369263e-02 -4.91808433e-03 -1.22315291e-01]
[ 1.43242032e-01 -2.84650392e-01 -1.62986512e-02  5.50838836e-02
 -2.13679817e-01 -5.70465612e-02 -2.10909286e-02  6.59536085e-02
  9.98983488e-02 -5.52450910e-02 -1.51427815e-01  1.21754269e-01
  1.08397193e-01 -5.78666151e-02  2.25525363e-02]
[ 2.29132589e-02  3.78057385e-02  1.32228039e-02  1.26188035e-01
 -1.84182098e-01  6.57503474e-02  2.46242918e-02 -3.82919316e-02
  9.23038171e-02 -2.49285421e-01  1.03113902e-01  2.35806324e-02
 -1.26762455e-01  3.15889006e-02 -4.30117423e-02]
[ 2.43231949e-01  1.64686619e-01  3.68632792e-02 -8.64310551e-02
 -6.87413008e-02 -7.08868904e-02 -6.94676263e-02 -1.06831344e-01
 -8.41849465e-02 -4.25657266e-02 -6.47457554e-02 -8.49108270e-02
 -1.06359602e-01  2.43306897e-01 -1.59937299e-01]
[-1.17421669e-01  2.44096350e-02 -3.95526351e-02  2.78972914e-02
```

```
  6.95331775e-02  8.79231404e-02  6.17712168e-02 -1.15962139e-01
  8.58524159e-02 -1.91422711e-01 -2.44841628e-02 -6.48489004e-02
 -1.19534480e-01  4.74471467e-02 -3.09305185e-02]
[ 8.67586576e-02 -1.66983755e-01  7.74584054e-02  3.53500447e-02
  2.29517018e-03 -1.79984953e-01 -3.85649442e-02 -1.71198496e-01
 -2.33203805e-01  3.13096011e-01  8.40881386e-02  1.64272316e-01
 -5.63106995e-02  5.79314482e-02  5.71792795e-02]
[ 4.48604736e-02 -1.84743541e-02 -3.00291204e-02 -2.21460447e-01
  5.06175230e-02  3.98301730e-03  9.83499431e-02 -4.40229647e-02
  1.49104866e-01 -5.96920355e-02 -1.38595376e-01  7.87711089e-02
 -6.02994358e-02 -1.37205170e-01 -1.33805028e-04]
[ 6.06098163e-02  5.59196721e-03  4.26458759e-02  3.96607916e-01
  7.18793798e-02  1.15305922e-01 -2.11803577e-01  2.01792997e-02
  5.27094226e-02 -5.11462227e-02 -1.00438808e-01  2.48538173e-02
 -4.47054812e-02 -7.09206118e-02  1.02535372e-01]
[ 1.18293881e-01  1.14564510e-02 -5.26156286e-02  3.69637386e-02
  7.25667889e-02  2.47515269e-02 -1.58751210e-01 -5.03701866e-02
  1.08802748e-02  4.73077140e-02  8.30494119e-02  6.08189023e-02
 -1.26871780e-01 -8.24549238e-02 -1.34736417e-01]
[ 1.65308490e-01 -6.24283421e-04  4.81782743e-02  8.89472417e-02
 -4.31967579e-02 -1.53174453e-01 -5.59578762e-02 -3.12492696e-02
  1.25293180e-01  7.21658855e-02 -1.21632767e-01  5.15261882e-02
  6.01576670e-02 -1.17755062e-01 -2.33446405e-02]
[-2.00319594e-01  1.42207805e-02 -3.87630118e-02 -1.49485020e-01
 -8.02008684e-02 -1.43465106e-02 -6.87195477e-02  1.33669483e-02
  3.02043515e-02 -9.89740344e-02 -4.42679215e-02  1.99436885e-01
 -1.34314452e-03 -9.64014059e-02 -6.55716529e-03]
[-1.49149664e-01  9.44319389e-02  2.98293519e-02  9.40849826e-02
  7.98245029e-02  6.68740718e-04  8.41156215e-02  2.56018748e-03
 -9.12981005e-02 -1.17293036e-01 -5.78691103e-02 -2.65588114e-01
  1.69135419e-01 -1.83135791e-01 -2.02785957e-02]
[-1.47012365e-01 -2.21349210e-01 -1.54060376e-02 -4.49358000e-02
 -2.63403963e-02  1.65947778e-02 -7.52458474e-02  2.13135981e-02
  2.62982963e-02 -4.83896605e-02 -4.13712034e-02  3.88294891e-02
 -7.70848302e-03  4.20623322e-03 -2.50021001e-01]
[-9.38580282e-03  1.88818651e-02 -2.07243168e-02  1.91420937e-02
  1.80079400e-01 -2.97019502e-02  5.31422737e-02 -1.01541764e-01
 -1.10225832e-01 -6.28877084e-02 -1.14970906e-01 -1.57528882e-02
 -1.06800821e-01 -2.91897377e-02 -1.56284265e-01]
[-1.80304792e-01 -8.61481335e-02 -1.13804936e-01 -7.95970738e-02
 -7.14582442e-02 -7.30049026e-02  9.12927582e-02  1.20522229e-01
  4.77848097e-02 -5.06856245e-02  1.36822463e-01 -1.67953331e-01
 -2.15619050e-01  1.52294981e-02 -1.26592635e-02]
[-2.91119925e-02 -1.54540840e-02 -1.71201217e-01 -1.30062312e-01
  1.13088322e-01  6.46987661e-02 -8.55260949e-02  1.76833617e-01
 -1.31991010e-01 -7.19731076e-02  1.62858996e-02 -1.34435116e-01
 -6.21615548e-02 -2.89484699e-02 -5.20562171e-02]
[ 7.19334613e-02  4.06011533e-02 -1.17059424e-01 -8.25094260e-02
  7.71484526e-03 -4.47248860e-02 -9.20807014e-02  2.60322188e-02
  5.71294201e-02 -7.79162461e-02  6.59755557e-02 -1.77066479e-01
 -1.74389431e-01  3.83802771e-02 -9.59480434e-02]
[-1.14876354e-01 -4.50647413e-02 -7.48883807e-02  1.83218714e-02
 -1.55854160e-01 -7.53037461e-02  3.02763161e-01 -5.47871722e-03
 -2.16269842e-01  4.51472059e-02  4.19802157e-02  1.23449463e-01
  1.46917132e-03 -7.69957232e-02  1.28357118e-01]
[ 5.59297412e-02 -1.98897784e-01  6.75645773e-02 -3.77718007e-02
  1.00680464e-01 -7.56724743e-02  6.51919450e-02  2.83499977e-03
```

```
  3.35630268e-02 -1.69662333e-02 -5.44802318e-02 -8.29687016e-03
  4.97286469e-02  3.00410424e-02  1.48914610e-01]
 [ 2.74182278e-02  4.48793846e-02  2.03089614e-01 -7.75270235e-03
  4.32613688e-02 -9.84063245e-02 -9.11574695e-03  1.47745776e-01
  6.30924131e-03  1.30322470e-01 -1.19415695e-01 -1.54988714e-01
  1.74185649e-02 -1.48583060e-01  2.54545317e-01]
 [ 1.09614988e-01 -1.43351180e-01 -2.38939138e-02 -7.20972213e-02
  3.12476618e-02 -4.40404165e-02  7.98078499e-02  1.30303672e-01
 -4.71222294e-02 -1.32198673e-01  4.32659028e-02 -3.14324532e-02
  1.01075346e-01 -2.68952366e-02  7.04114192e-02]
 [ 1.83272656e-02 -3.77338619e-02 -5.21311820e-02  5.68667595e-02
  2.42585755e-01  4.54193905e-02 -2.65945890e-02  5.41745013e-02
 -1.36545049e-02 -1.43020161e-01  1.79421079e-02  1.39797294e-01
 -4.50368647e-02 -1.24312645e-01  3.62431071e-02]
 [ 1.68480524e-01  7.59692717e-02  9.49781206e-02  2.16378638e-01
  1.52172419e-01  3.42331812e-02 -3.37121472e-02 -2.11050843e-03
 -3.44053446e-02  7.05556767e-02 -1.00785056e-01  1.40159273e-01
  1.71689178e-03 -5.12217030e-02  6.94645958e-02]
 [-2.22747070e-01 -1.02236393e-01 -7.29522072e-02  6.75917306e-02
 -5.92819118e-02  1.04207377e-01 -5.80906284e-02  3.55485672e-02
 -9.58437144e-02  1.00648071e-01 -3.84719495e-02  3.68832419e-02
 -6.27319821e-02 -1.20354652e-01 -3.56726287e-02]]
```

bias2

```
[[ 0.05999027]
[-0.15112209]
[-0.20253909]
[-0.08071529]
[ 0.02810024]
[-0.15549114]
[-0.10400817]
[-0.03152781]
[-0.08240602]
[-0.02116982]
[ 0.06936034]
[-0.04779211]
[-0.05648127]
[ 0.02674657]
[-0.05594895]
[-0.14459693]
[-0.15106288]
[-0.16102056]
[ 0.14158821]
[-0.05444283]
[ 0.00807848]
[ 0.02196695]
[-0.14382386]
[ 0.01461647]
[-0.10629403]]
```

Weight3

```
[[-0.23407024 -0.04267368 -0.1294445  -0.05843654  0.01017132  0.20531
829
  -0.0716322  -0.04073158  0.01076193 -0.00617553 -0.04164491 -0.131270
67
  -0.11878797 -0.04127861 -0.13832298 -0.08687667 -0.14698476  0.090921
31
```

```
  -0.17546134  0.16594655 -0.08369314 -0.13058988 -0.14249476  0.049908
98
   0.07999643]
 [-0.10906254  0.01290166 -0.03595416 -0.04781945 -0.00798608  0.054563
29
  -0.21276537 -0.24601782 -0.00459334 -0.0308431   0.04378671 -0.192737
51
  -0.12078199  0.13240641 -0.15240215  0.01615675 -0.100382   -0.061124
25
  -0.16234439  0.09539622 -0.21493049 -0.1438293  -0.11418091  0.090813
78
   0.00823831]
 [ 0.04241703 -0.02311993  0.00147294  0.02455073  0.13026799  0.001550
13
  -0.16912163  0.09016319 -0.01707164 -0.13578671 -0.04365276 -0.121453
85
   0.18534133 -0.05760446 -0.22274523  0.00903932 -0.10501825  0.107162
03
  -0.01240658 -0.2023241  -0.07595465 -0.13413095 -0.10021331 -0.092653
28
  -0.22373976]
 [-0.00578156 -0.1088582  -0.1114049   0.05043619  0.16543055 -0.085951
19
   0.15905176 -0.23007549  0.02974844 -0.08315031 -0.0333215  -0.121735
39
  -0.08270613 -0.05453117 -0.05714169  0.019945    0.21069629 -0.085033
34
  -0.04123802 -0.19929657 -0.27773097  0.11390132 -0.15726588 -0.102727
06
  -0.02064418]
 [ 0.06586542  0.01041177  0.16473297 -0.04282796 -0.20691616 -0.008982
86
  -0.01005478 -0.10616462 -0.05959904 -0.08340478  0.14771345 -0.084195
56
  -0.16241182  0.00505944 -0.20450964  0.02165447  0.01891335 -0.105903
97
  -0.08159587 -0.08424732  0.13589622  0.01445897 -0.14454055 -0.152717
12
  -0.03036166]
 [-0.02701726 -0.09834055  0.00685207 -0.04474577  0.08315976  0.020445
43
  -0.03170397 -0.01114647 -0.11505441  0.06327038  0.01214023 -0.065040
65
  -0.01170905 -0.0769853   0.2260187  -0.06657297  0.02969581  0.014578
28
  -0.10590114 -0.02404961 -0.05812229 -0.00052181  0.00105388  0.048328
23
   0.05527755]
 [-0.06596666 -0.07363402 -0.08089735 -0.11086376 -0.19840922  0.037457
71
  -0.02999013 -0.04543437 -0.19214237 -0.17490274 -0.27731538 -0.033247
71
   0.04382396  0.03651512 -0.03012792 -0.12895007 -0.0227134  -0.021266
4
   0.04492748  0.05235986 -0.05224784 -0.02853767  0.04542877  0.017713
71
  -0.03970808]
```

```
 [-0.24325826 -0.08861823  0.06097514 -0.01072987  0.07011218 -0.058465
17
  -0.0149858   0.0539543   0.04124049  0.01325901  0.08196626  0.109544
84
   0.11489539 -0.18912242 -0.07195687 -0.0548845  -0.05926128 -0.186232
82
   0.10331621 -0.12543863 -0.01681503 -0.26661153 -0.07597691 -0.055050
55
  -0.11724639]
 [ 0.04714187  0.21594477 -0.11045539 -0.11223522  0.14997396  0.032260
3
  -0.05462311 -0.153356    0.04572331 -0.00459499  0.1283316  -0.111084
73
  -0.04149824 -0.05475266 -0.04501166  0.08373252  0.06143386 -0.086516
13
  -0.03602973 -0.04839009  0.06214739 -0.04381448 -0.13706621 -0.063774
81
  -0.02844066]
 [ 0.06536695  0.10551526  0.10621895  0.01074046 -0.07695905  0.034224
63
  -0.04206668 -0.08788286  0.00143175  0.01416298  0.05948025 -0.114438
01
  -0.19146562  0.02599815 -0.12042346  0.07702058 -0.13360069 -0.081446
09
  -0.20857695  0.17839987 -0.07379899 -0.03574176 -0.07924088 -0.054643
12
   0.05774374]
 [-0.01677537 -0.02431367  0.09506826 -0.16197202  0.08691801  0.134481
85
  -0.1629832   0.00067201 -0.15725281 -0.23810707 -0.11281701  0.027286
43
   0.05046609 -0.06187689 -0.11106512 -0.06708112 -0.09566309 -0.086702
51
  -0.26880493 -0.0502524  -0.039653    0.19085297  0.04125183 -0.044392
16
  -0.01762968]
 [ 0.00500326 -0.09385349 -0.23276632 -0.10030397 -0.04948226 -0.014071
29
  -0.09648608 -0.11943208 -0.05573269 -0.02235291  0.02837428 -0.050103
66
   0.01778801 -0.12573516  0.05612884 -0.0296289  -0.16102694 -0.049656
44
  -0.01794436 -0.13351231  0.04400002 -0.06124791  0.01846323 -0.130420
28
   0.00562358]
 [ 0.0442121  -0.0682484  -0.04420159 -0.0848518   0.00611049 -0.022788
88
   0.02500802 -0.03327222 -0.15659823 -0.15909091 -0.07374071  0.020183
75
   0.20027711  0.06107896 -0.08650515 -0.22647658  0.02679199 -0.022526
87
  -0.14979805  0.06241474 -0.02768083 -0.06906285 -0.22014383  0.065841
1
  -0.01842103]
 [-0.0530024  -0.11999687 -0.06128014  0.0964689   0.0255135   0.175038
94
   0.0818231   0.0078745   0.06089081 -0.01102415 -0.17319061 -0.085674
```

```
51
   0.00799072 -0.1186033  -0.07634269 -0.14795188  0.14495101 -0.155591
01
  -0.13208681 -0.1152098   0.06934239  0.08545934 -0.08178457  0.027263
62
  -0.11399936]
 [-0.02707956  0.23833853  0.07076435 -0.03072145 -0.1585695  -0.054667
47
  -0.15583491 -0.24461733  0.03248642  0.03179676 -0.00744638  0.075438
39
  -0.19182125  0.11533377 -0.13212756  0.01546974  0.02241433  0.085034
18
   0.17289649  0.00931285 -0.06496542 -0.13744024  0.00060644 -0.114001
21
  -0.15943158]
 [-0.04664391  0.04504332 -0.05386045 -0.13100831 -0.01100603 -0.148318
68
  -0.17481585  0.120535   -0.00321124  0.1721505  -0.17434078  0.079737
68
  -0.04179195  0.24403987 -0.04483685 -0.06644411  0.01961251 -0.003544
93
  -0.0726702   0.0659049   0.04229479  0.06241944  0.01481087 -0.100163
  -0.09365595]
 [ 0.03292732 -0.11598708  0.14693165 -0.02243762 -0.10459955  0.079837
26
  -0.02500851  0.09434413 -0.00633303  0.15094618 -0.06523921 -0.242382
78
  -0.17573784 -0.18732356  0.03568453  0.15890592 -0.04228371 -0.155887
15
   0.04152309  0.02008851 -0.06485241  0.01463293 -0.02460184 -0.144233
37
   0.04492292]
 [-0.07662444 -0.11685836 -0.04631557  0.1313277   0.17126827  0.116299
06
  -0.07229958 -0.12787677  0.00710517 -0.04186789 -0.01276834 -0.136799
25
  -0.11253283 -0.13131335  0.05416752  0.08441398 -0.09084532  0.036002
88
   0.03760804 -0.09906705 -0.02553133  0.05539738 -0.1265023   0.095648
12
  -0.0440515 ]
 [-0.01933347 -0.04558804 -0.17010128  0.00928375 -0.02481392 -0.063932
05
  -0.04403016  0.01741435 -0.04112019 -0.07783244 -0.01773774  0.052455
54
  -0.01951535 -0.10254256  0.06076234 -0.050725    0.03671226 -0.036107
35
  -0.12008645 -0.15174646 -0.11568354 -0.04849202 -0.2494678   0.010285
96
   0.0873143 ]
 [-0.05034209 -0.13282225 -0.18936194 -0.00291974  0.01624973 -0.017936
42
   0.04685614 -0.09238098 -0.05252061  0.00192902 -0.0492522   0.024980
82
   0.02566777 -0.0508868  -0.11948024 -0.09423768  0.08698988 -0.142656
91
  -0.02055052 -0.12468517  0.20421509 -0.08937824  0.03835616 -0.125805
```

```
25
   0.29577497]
 [-0.15816304  0.01510256 -0.14659871  0.05801058 -0.14901568 -0.066607
25
  -0.18091426 -0.06338537 -0.02555692  0.15002964 -0.25534211  0.032194
45
  -0.01824696 -0.08315153 -0.04289891  0.01859569 -0.02494454 -0.025294
27
  -0.10297833 -0.06363979  0.02350225 -0.11659971 -0.07539995 -0.019867
6
   0.01060534]
 [ 0.0123772  -0.04215667 -0.22618707  0.05060822  0.07510846  0.095666
8
   0.0110888   0.05910974 -0.05706964 -0.13716674 -0.04426827 -0.048799
46
   0.0751848   0.05549649 -0.07543988 -0.06478649 -0.02793857 -0.016025
49
   0.11383686 -0.07528743  0.10064359 -0.166197   -0.09441991  0.135747
1
   0.01381636]
 [-0.01813183  0.03482995 -0.04627967 -0.02212975 -0.00545822 -0.004101
81
   0.01073617 -0.08509415  0.00633249 -0.09883971  0.02916074 -0.042737
23
  -0.00147849  0.00166053 -0.09911511 -0.07734954 -0.03915272  0.020068
53
   0.06462979 -0.03265975 -0.09656912 -0.00429483 -0.02938986  0.043748
69
   0.0942623 ]
 [ 0.16517042 -0.18814218 -0.072195   -0.03532139  0.05015941  0.041021
51
  -0.01941957  0.04876247 -0.084411   -0.06436309  0.00085284 -0.132055
18
   0.12973324 -0.10475304 -0.13770658  0.00764047 -0.21487593 -0.067200
91
  -0.04532692  0.10004858  0.27417857 -0.01102438 -0.15509331 -0.005140
71
   0.04063446]
 [-0.11936594  0.01070339  0.13250998  0.02161207 -0.10442811 -0.080618
69
  -0.18719329 -0.06989523 -0.08635857  0.11066958 -0.18199349 -0.181809
02
  -0.00652568  0.03333488 -0.07924489 -0.00434384  0.04201078  0.049389
28
   0.00823529  0.0269781  -0.18171039  0.05184515 -0.01281129 -0.112722
06
  -0.06422309]]
```

bias3

```
[[-0.07838111]
 [-0.10161939]
 [-0.06616435]
 [-0.08837373]
 [-0.19367006]
 [ 0.16354261]
 [-0.01156939]
 [ 0.16829909]
```

```
 [-0.07915205]
 [ 0.1086945 ]
 [-0.0630346 ]
 [ 0.10513883]
 [ 0.0404267 ]
 [ 0.02414327]
 [-0.06903908]
 [-0.02960827]
 [ 0.08130009]
 [-0.24940741]
 [-0.11755423]
 [-0.17501587]
 [-0.13901756]
 [ 0.01048012]
 [ 0.03204225]
 [-0.07081423]
 [ 0.06185239]]
```

Weight4

```
 [[-0.09407775 -0.07810364 -0.00868581  0.01925951 -0.03336323 -0.13616
006
   0.03620422  0.14457909 -0.06324068 -0.0239539  -0.13152397 -0.022053
41
  -0.11437423 -0.00797887  0.13075452  0.02578435 -0.0983174   0.057432
79
  -0.19184124  0.09771853  0.01140992 -0.1334062  -0.05909558 -0.115976
51
   0.17561548]
 [ 0.03632372 -0.11880537 -0.08802368 -0.0052356  -0.0774626  -0.006724
6
   0.0169475  -0.16991058  0.03458507  0.13962303  0.01011237  0.039565
77
  -0.07514456 -0.07653106  0.00573378 -0.11477861 -0.1874983   0.058716
48
  -0.085363   -0.00198413 -0.00822085  0.01238844  0.03197416  0.026206
75
  -0.0529372 ]
 [ 0.06066801 -0.05431987  0.01431512 -0.08268403 -0.01223279 -0.114417
68
   0.11788281  0.00728108 -0.09890831 -0.20491464 -0.09352049  0.107725
21
  -0.08779095  0.07187264 -0.04610238 -0.06012835 -0.13181931  0.004485
58
   0.08122439  0.05339517  0.03182793 -0.13214276 -0.01866909 -0.140813
92
  -0.10973032]
 [ 0.01464591 -0.12623868  0.02520469 -0.05429185  0.12001722 -0.048240
24
   0.02491135  0.07110045  0.02776906  0.03242005 -0.19827603  0.061858
67
  -0.18943975 -0.09841786 -0.27370515 -0.06628124 -0.09977775 -0.053838
28
  -0.12520711 -0.04683242 -0.09875822 -0.05391769  0.04779718 -0.249305
54
  -0.03559319]
 [-0.04434201 -0.18118522 -0.07308761  0.11209885  0.00720646 -0.094585
39
```

```
   0.04391251  0.00205764 -0.16253028 -0.0717595  -0.03392142 -0.028838
29
   0.00238173 -0.03281664 -0.02734606 -0.08784905 -0.07122023 -0.082844
65
   0.02234278 -0.04253978 -0.08497626  0.03954015  0.20729243 -0.046988
93
   0.09611979]
 [-0.07978242 -0.00246432  0.06482525  0.08689409  0.18830401 -0.080314
42
  -0.01430761  0.10860177  0.10255769 -0.11205958 -0.02191872  0.078627
64
   0.0989726  -0.11933173  0.012063   -0.24769983  0.07551039  0.153297
14
  -0.1289799  -0.04415903 -0.15972002 -0.07284358  0.02799201  0.033586
87
   0.01789916]
 [-0.15857758 -0.1017983   0.16627894  0.00310598 -0.06204708 -0.003753
14
  -0.0775484  -0.00787999 -0.10161417 -0.09326768 -0.17675069  0.153954
63
   0.04910038  0.03775573  0.06355271 -0.03836352 -0.13376096  0.028843
84
   0.04937319  0.03151961 -0.05716278 -0.17769098  0.05311279  0.016309
02
  -0.02829013]
 [-0.04275548 -0.03016047 -0.07596196 -0.16663557 -0.02984052 -0.071693
01
   0.0126165  -0.05491497  0.0035605  -0.14596616  0.02505541  0.185832
95
  -0.03226023  0.03858066  0.06453466  0.00994971 -0.00109798 -0.177689
79
  -0.10075685  0.13247987  0.00268468 -0.00530893  0.16820114 -0.195324
64
   0.08312058]
 [ 0.04592824 -0.21146652 -0.082855    0.02307936 -0.0891521  -0.104699
8
   0.04154804 -0.04253211 -0.00568824 -0.04148583 -0.0064542   0.009725
23
   0.19869502  0.01645785 -0.0927824   0.01282349  0.00082997  0.308816
98
  -0.16120355  0.04755122  0.00838112  0.12670312 -0.12761259 -0.147332
22
   0.01322562]
 [ 0.06458443  0.02692318  0.04357835 -0.0239683   0.08128427 -0.015514
19
  -0.06948364  0.12292433 -0.11097805 -0.18567213 -0.05945659 -0.034446
32
  -0.02880528 -0.05413807  0.01460253 -0.05945427 -0.11217717  0.117798
9
  -0.03669146  0.08743003 -0.00046007  0.02202258  0.12834167 -0.209950
42
   0.09042579]]
```

bias4

```
[[-0.04310091]
 [ 0.03751119]
 [-0.09339319]
```

```
 [-0.04640459]
 [-0.06490095]
 [-0.15981835]
 [-0.05600278]
 [ 0.13156289]
 [ 0.07795976]
 [ 0.09109806]]

 Weight5
 [[-0.04582835 -0.04186661 -0.06484845 -0.2245137  -0.04713479 -0.09966
496
   0.06379172  0.06624243  0.01671737 -0.11613209]]

 bias5
 [[-0.10855453]]
```

In [464]:
```
print(y_hat)
```

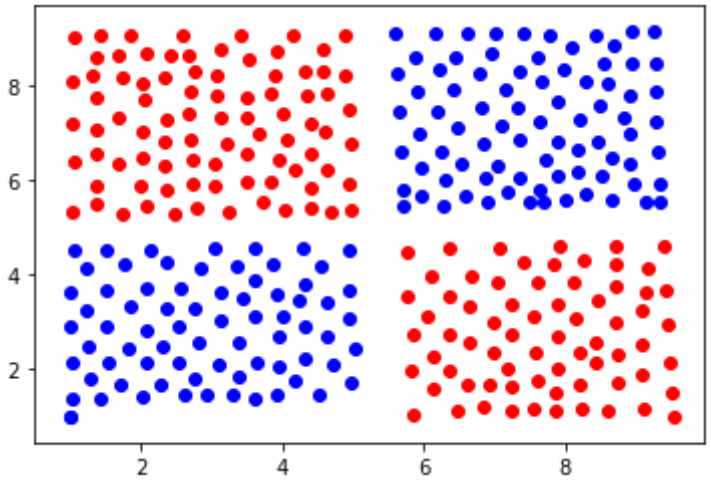
```
[[0.44068271 0.44068562 0.4406895  0.44069496 0.44069826 0.4407018
  0.44070494 0.44070498 0.44070497 0.44070528 0.44070522 0.44068265
  0.44068285 0.44068329 0.44068361 0.44068617 0.44068982 0.4406933
  0.44069692 0.44070023 0.44070318 0.44070778 0.44070786 0.44070803
  0.44070811 0.44070823 0.44070833 0.4407105  0.44071253 0.44071419
  0.44071549 0.44071696 0.44071799 0.44071039 0.44071297 0.44071512
  0.44071669 0.44071779 0.44071832 0.44071829 0.44072133 0.44072136
  0.44072148 0.44072118 0.44072122 0.44068578 0.44068595 0.44068648
  0.44068952 0.44068941 0.44068967 0.44069246 0.44069341 0.44069364
  0.44069663 0.44069699 0.44069685 0.44069953 0.44069931 0.44069964
  0.44070285 0.44070284 0.44070286 0.44071032 0.44071026 0.44071047
  0.44071061 0.44071247 0.44071235 0.44071229 0.44071216 0.44071385
  0.44071544 0.44071531 0.44071538 0.44071538 0.44071728 0.44071728
  0.440717   0.44071901 0.44071883 0.44071889 0.44071909 0.44071988
  0.44071983 0.44071983 0.44071984 0.44071951 0.44068438 0.44068761
  0.44069124 0.44069401 0.44069685 0.44069983 0.44070315 0.44068442
  0.44068856 0.44069152 0.4406939  0.44070011 0.44070351 0.44070351
  0.44068421 0.44068791 0.44069104 0.44069403 0.44069816 0.44070066
  0.44069809 0.44070097 0.44070204 0.44070086 0.44068644 0.44068902
  0.4406926  0.44069539 0.44069902 0.44069653 0.44070036 0.44070244
  0.44070464 0.44070915 0.4407091  0.44070919 0.44070954 0.44070954
  0.44071172 0.44071121 0.44071275 0.44071393 0.44071452 0.44071089
  0.44071124 0.44071322 0.44071468 0.44071337 0.4407114  0.44071163
  0.44071325 0.44071598 0.44071586 0.44071438 0.44071591 0.44071769
  0.44071752 0.44071663 0.44071844 0.44071837 0.44071957 0.44071773
  0.44071798 0.4407186  0.44071955 0.44071657 0.44068247 0.44068238]]
```

Question 2. Once your network has been trained, use meshgrid to display the classification boundary below

Solution

In [485]:
```
import numpy as np
import matplotlib.pyplot as plt
from matplotlib.colors import ListedColormap
from scipy.optimize import minimize


def plot_neural_network(data_class1, data_class2):

    data = np.vstack((data_class1, data_class2))
    xmin = np.amin(data[:,0])
    xmax = np.amax(data[:,0])
    ymin = np.amin(data[:,1])
    ymax = np.amax(data[:,1])

    xequispaced = np.linspace(xmin, xmax, 100)
    yequispaced = np.linspace(ymin, ymax, 100)

    xx, yy = np.meshgrid(xequispaced, yequispaced)

    grid_data = np.vstack((xx.flatten(), yy.flatten())).T

    parameters = weights_layer(Network_size, 2)

    label_mesh, memory = Forward_propagation_complete(X, parameters, Net
work_size) # use your forwardProp implementation

    prediction = np.array([np.argmax(activation) for activation in label
_mesh])

    plt.scatter(data_class1[:,0], data_class1[:,1], c = 'r')
    plt.scatter(data_class2[:,0], data_class2[:,1], c='b')
    plt.show()

    prediction = clf.predict(grid_data)

    Z = prediction.reshape(xx.shape)

    colors = ('red', 'blue', 'lightgreen', 'gray', 'cyan')
    cmap = ListedColormap(colors[:2])

    plt.contourf(xx,yy,Z, alpha = 0.1, cmap=cmap)
    plt.xlim(xx.min(),xx.max())
    plt.ylim(yy.min(),yy.max())

    plt.scatter(data_class1[:,0], data_class1[:,1], c = 'r')
    plt.scatter(data_class2[:,0], data_class2[:,1], c='b')
    plt.show()

    return

plot_neural_network(data_class1, data_class2)
```

```
Shape of Prediction Vector: (1, 156)
Memory dictionary size: 10
Prediction Vector is:
[[0.45978053 0.45978221 0.45978444 0.45978758 0.45978952 0.45979102
  0.45979246 0.45979191 0.45979137 0.45979103 0.4597932  0.45977925
  0.45977867 0.45977814 0.45977768 0.45977895 0.45978106 0.45978315
  0.45978543 0.45978754 0.45978884 0.45979214 0.45979216 0.4597923
  0.45979234 0.45979205 0.45979156 0.45979269 0.45979395 0.45979515
  0.45979654 0.45979822 0.45979947 0.45979133 0.4597938  0.45979779
  0.45979896 0.4597999  0.45980024 0.4598     0.45980382 0.45980385
  0.45980393 0.45980369 0.45980372 0.45978117 0.4597806  0.45978012
  0.4597827  0.45978257 0.4597819  0.45978361 0.45978183 0.45978197
  0.45978387 0.45978341 0.45978339 0.45978518 0.45978507 0.45978464
  0.45978693 0.45978694 0.45978691 0.45979238 0.4597923  0.45979245
  0.45979257 0.45979388 0.45979376 0.45979373 0.45979361 0.45979495
  0.4597967  0.4597998  0.45979985 0.45979985 0.4598011  0.4598011
  0.45980072 0.45980213 0.45980201 0.45980206 0.4598022  0.45980269
  0.45980266 0.45980266 0.45980267 0.45980235 0.45977931 0.45978118
  0.45978331 0.45978497 0.45978702 0.45978763 0.45979002 0.4597789
  0.45978091 0.45978263 0.45978407 0.45978797 0.45979064 0.45979123
  0.45978025 0.45978161 0.45978302 0.45978446 0.45978456 0.45978679
  0.45978512 0.45978698 0.45978772 0.45978643 0.45977729 0.45977883
  0.45978042 0.459782   0.45978355 0.45978229 0.45978402 0.45978632
  0.45978796 0.45979155 0.45979209 0.45979212 0.45979146 0.45979144
  0.45979287 0.45979242 0.4597939  0.45979564 0.45979665 0.45979384
  0.45979296 0.45979562 0.45979661 0.45979715 0.45979566 0.45979582
  0.45979709 0.45979971 0.45979974 0.45979882 0.45979976 0.45980105
  0.45980074 0.45979985 0.4598014  0.4598014  0.45980246 0.45980115
  0.45980141 0.45980199 0.45980258 0.45980063 0.4597795  0.45978001]]
```



Reach out if Something is unclear

PDF is attached

End of Code